UPPER PALEOZOIC STRATIGRAPHY OF THE AREA BETWEEN BANFF AND JASPER ALBERTA

R.A.HOWARD

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Plate 1

Flatirons in the Rundle formation on the east side of Coral creek, making the west slope of the third range of the Rocky Mountains.

THE UNIVERSITY OF ALBERTA

UPPER PALEOZOIC STRATIGRAPHY OF THE AREA BETWEEN BANFF AND JASPER, ALBERTA.

A DISSERTATION

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R. A. HOWARD

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ABSTRACT

Nine upper Paleozoic sections from between Banff and Jasper have been examined paleontologically and lithologically, and found to comprise the Greenock and Rundle formations as previously known in the Mt. Greenock area (3), 12 miles north-east of Jasper town, Alberta. Members of the Greenock formation are present as in the type area.

The Greenock formation occupies the same position in the sequence as, and is lithologically similar to the Rocky Mountain formation of the Banff area. Warren (29) has shown the Rocky Mountain formation to be largely Pennsylvanian, whereas Brown (3) has indicated an upper Mississippian age for the Lower member of the Greenock formation. The boundary between the Rundle and Greenock or Rocky Mountain formations can therefore be considered diachronic as the result of a regressive overlap of deposition during the withdrawal to the south of the upper Mississippian and Pennsylvanian sea of the Rocky Mountain trough. The conditions suitable for the development of siliceous dolomite beds occurred at an earlier time in the north, so that this facies becomes higher in the section towards the south.

The Greenock formation is believed to be present in the Brazeau range as the latest Paleozoic strata previously (5)(10) known as the upper member of the Rundle formation.

The Rundle formation consists of four members which can be identified in all sections presented, and in the Rundle formation of the Mt. Greenock area and the Brazeau range. A correlation to the Rundle group of the Front Ranges (6) in Southern Alberta is suggested.

The lithologic relation to the type section at Banff is not apparent in detail.

No definite conclusions have developed from a study of the fauna. In general a lower Mississippian age is indicated for the lower part of the Rundle, and an upper Mississippian correlation for the upper part of the Rundle and Lower member of the Greenock formation. Paleontological correlation with adjoining areas is possible for the lower part of the Rundle formation and to a lesser extent for the upper part. The Greenock formation lacks regional paleontological correlation.

CONTENTS

ILLUSTRATIONS

INTRODUCTION

The purpose of this thesis is to report nine detailed sections of the sequence of late Paleozoic beds known in the Canadian Rockies as the Rundle and Greenock or Rocky Mountain formations, and to determine a correlation to surrounding areas.

The material was obtained during the 1953 field season while working for Royalite Oil Co. as assistant geologist to party chief J. R. Stevenson. Eight sections, complete from the top of the Banff formation to the base of the Spray River Formation, were measured. Section number four is not complete, comprising only the upper half or so of the above sequence. Four sections of Banff formation were measured and described, these at localities of sections three, five, six and nine.

Sections are numbered chronologically as they were done in the field. Figure 1 indicates the location of these sections with respect to fault blocks or "ranges" shown on the map by "cliff" symbols which follow the position of the Devonian formations. The Palliser formation of Upper Devonian age is a constant guide to the position of fault blocks.

The most northwesterly section, No. 4, is 40 miles S. 78° E. from Jasper town. The most southeasterly section, No. 9, is approximately 60 miles N. 26° W. from Banff. Section 7 is on the fourth range of the Rockies-proper. The rest are on the first 3 ranges except numbers 1, 2 and 3 which are on the Bighorn Range, an outlying range, running northwest parallel to the Rockies for 30 miles from a point twelve

miles west of Nordegg. Section eight is the most accessible. One may drive to within 1/2 mile of it by following the David Thompson road west from Nordegg for 28 miles ($2\frac{1}{2}$ miles past Windy Point).

All sections except number eight were measured with a plane table, and are believed to be as accurate as is possible for this method. Number 8 was measured with a five foot stick and is less reliable as some covered intervals were estimated, and part of the section contained wide dip slopes which decrease the accuracy of this method considerably.

In describing the lithology in the field, no color chart was used, and gain sizes were not measured, so some variation from the standards is quite possible although samples have been studied since with regard to these features and appear, fortunately, to have been described correctly for the most part.

Sampling was done randomly where change in lithology seemed to require further examination. Of the samples collected, thin sections were made from 13, insoluble residue tests of 19, and some were studied closely under the microscope to determine grain size, structure and so on. This was carried out simply to provide some indication of the true nature of the rock types present so that nomenclature might be more reliable. Of course, due to the lack of concentrated sampling, descriptions cannot be regarded as correct throughout the sections, but it is felt that such analyses of samples as were made have given a much greater reliability to description than would have been possible from field notes alone.

It often would have been desirable to spend more time in collecting

from the relatively few fossiliferous horizons found. The collections obtained are by no means representative. However, more time would have been required to achieve an adequate study of any larger a collection. Sufficient material was collected to indicate a correlation of the fossiliferous horizons to other Mississippian sections in the Rockies of Canada and the U.S. and to the Mississippi type area.

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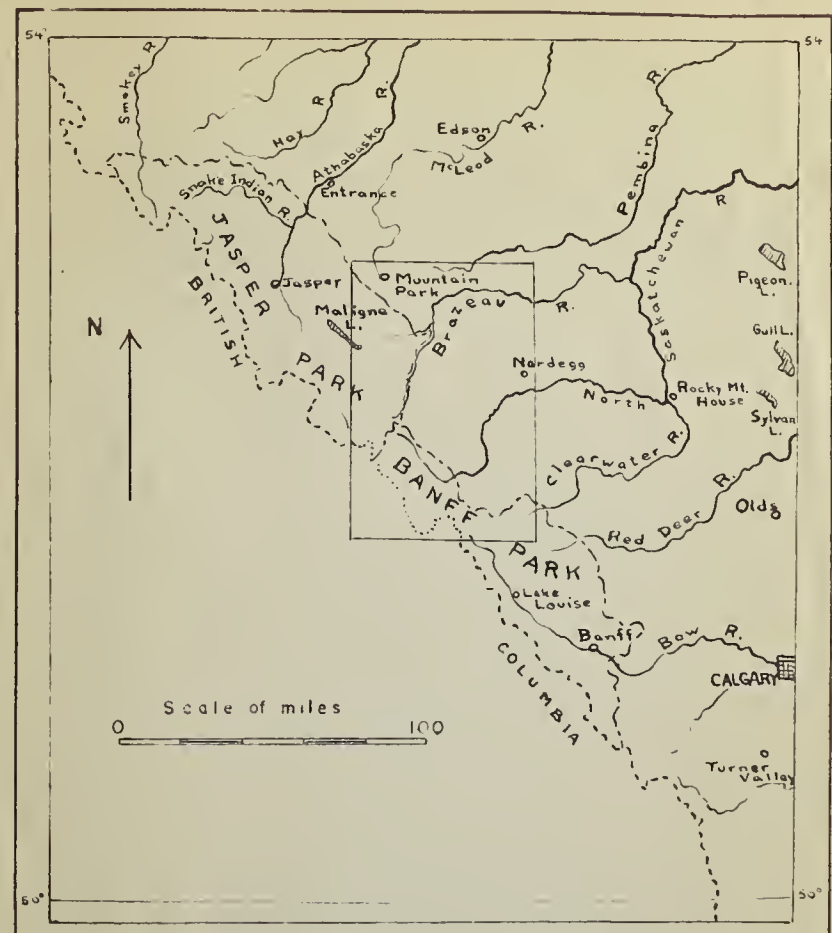
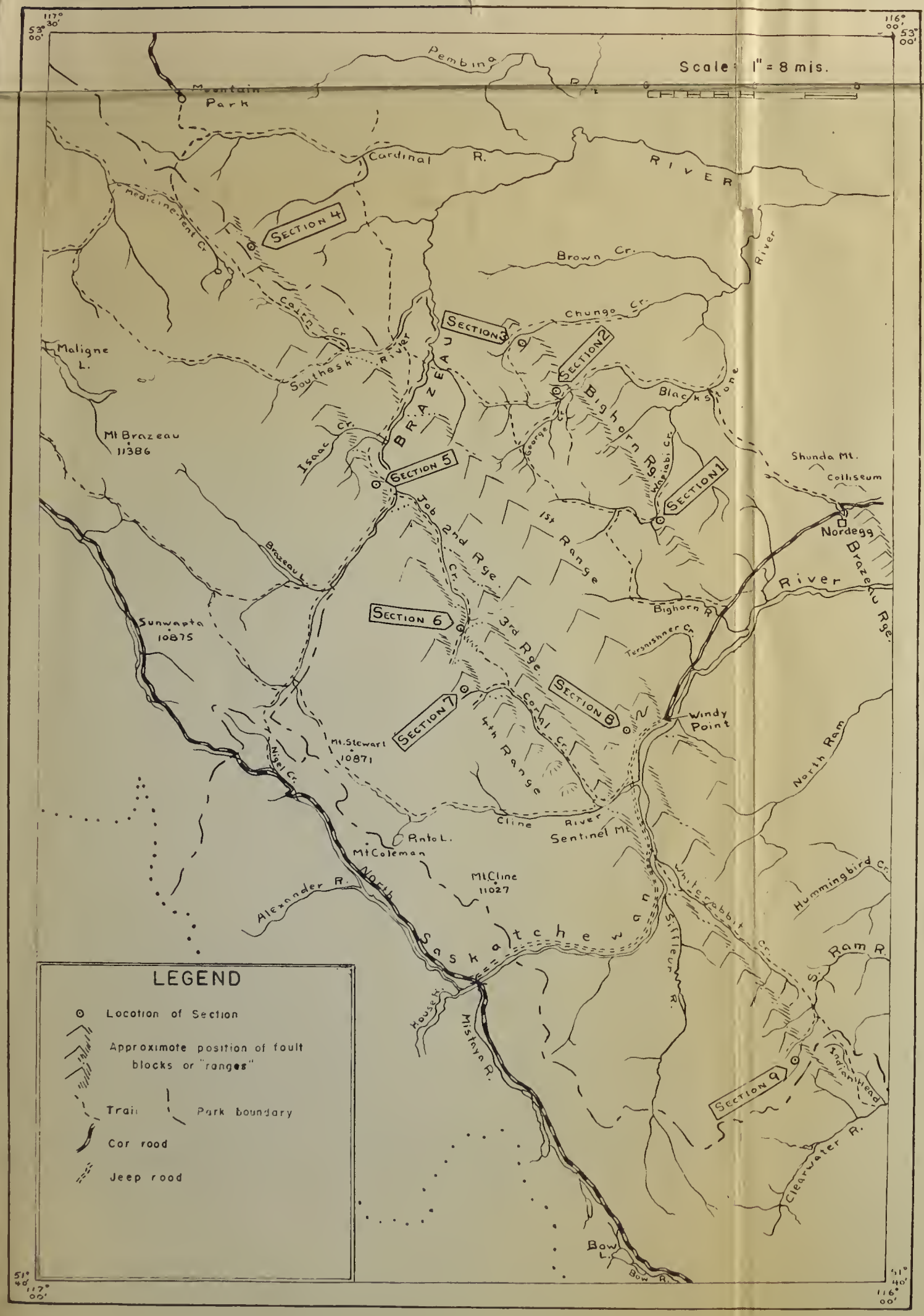
The writer is indebted to Dr. P. S. Warren for his guidance, and also to Dr. C. R. Stelck and C. P. Gravenor for their advice on many matters. Thanks are due Royalite Oil Company for allowing the use of the material, and especially Mr. J. R. Stevenson for his advice in the field. Acknowledgments are also due H. A. Sejbjerg, without whose careful surveying, much less reliability could be placed on measurements of sections.

Fig. 1

LOCATION OF SECTIONS

WEST CENTRAL ALBERTA
INDEX MAP





LEGEND

- Location of Section
- Approximate position of fault blocks or "ranges"
- Trail
- Park boundary
- Car road
- Jeep road

CHAPTER I

GENERAL STRATIGRAPHY

The late Paleozoic sequence concerned in this thesis has been divided into two formations, the Rundle and the Greenock. This division has been made largely on the basis of lithologic correlation to a similar sequence in the Mount Greenock area (3) northeast of Jasper town. In that area, R.A.C. Brown defined the Greenock formation as follows... "Between the massive to moderately bedded, dark, in places speckled, dolomitic beds of the Rundle formation, and the finely banded Triassic siltstones, there exist in the Mount Greenock area, light coloured strata consisting mainly of bedded, cherty dolomitic siltstone, massive chert, and quartzitic sandstone". The type section of the Greenock formation is on the southwest spur of Mt. Greenock. Brown divided the Greenock formation into three members. The same members are present in sections studied here, but the Upper member is present in only one section. It is assumed that during pre-Triassic erosion, the Upper member and a good part of the Middle member were removed from most sections.

As in the Mt. Greenock area, the Lower member consists of usually thin to medium bedded, fine crystalline dolomite, siliceous dolomite, and dolomitic siltstone, with chert lenses abundant at some horizons. The siliceous or silty content is believed to increase upward and southwestward, section 9 having well developed quartzite and chert bands in the upper part of this member. Argillaceous dolomites

are common in this member in the more easterly sections.

The Middle member is usually separated from the lower by a thin, phosphatic, pellet or pebble conglomerate. The Middle member consists of massive blue grey chert which becomes sandy near the base and the top where it is complete, but due to pre-Triassic erosion, the sandy top part is missing in some sections, and a more or less pure dark chert underlies Spray River (Triassic) shale and sandstone.

The Upper member is present in section 8 where also the thickest Middle member was found. The Upper member grades out of the Middle member by an increase in the amount of sand, and the boundary is placed where the sandstone or quartzite predominates over the chert. The brown grey, fine grained, thin to thick bedded quartzite and quartzitic sandstone of this member is separated from Spray River argillites by a 30 foot covered interval in section 8.

The lowest Spray River beds in the Rockies-proper are dark grey shales and siltstones which are from 30 to 50 feet thick and are overlain by grey brown, thin to very thin bedded, platy siltstones which are characterized by fine, wavy laminations. Two poorly preserved Ammonites found in these beds have been referred to the genus Ophiceras of the Meekoceras zone of lower Triassic age. In the Bighorn Range, the lowest beds assigned to the Triassic are thin bedded sandstones and quartzites and grey shale which overlie the massive chert of the Middle member of the Greenock formation. Above these sandstones there occur light grey, fine grained dolomites which may be Whitehorse (middle Triassic) correlatives. No fossils were found in these beds.

The Lower and Middle members of the Greenock formation appear to have been deposited under conditions similar to those which occurred during the deposition of the Rocky Mountain formation at Banff (29). On Mount Norquay, the upper 90 feet of the Rocky Mountain formation is nearly pure, usually grey, chert, resembling that of the Middle member of the Greenock formation which reaches a maximum thickness of 75 feet in section 8 of this report. The Rocky Mountain formation is principally light, fine grained, hard dolomite with varying amounts of silica present as massive chert beds, thin chert lenses, and silt or sandstone beds. The Lower member of the Greenock formation of section nine of this thesis differs from the more northerly sections in having a silica content nearly equal to that of the Rocky Mountain formation, and indicates a general facies change in the nature of a decrease in silica content to the north. The phosphatic content of the upper part of the Rocky Mountain formation is reflected by thin phosphatic sandstone beds within the Middle member of the Greenock formation.

The Upper member of the Greenock formation is apparently seldom preserved south of the Mount Greenock area, and, were it not for section 8, it would have been concluded absent from the whole area concerned in this thesis. It is apparently preserved locally, perhaps in areas which were low at the end of the Paleozoic time where pre-Triassic erosion was limited. That this member is Paleozoic is indicated by the gradational contact with the Middle member, whereas all contacts accepted as Paleozoic-Mesozoic are sharp, although apparently conformable in any one section.

To the east of the area concerned in this thesis, in the Alexo[5] and Saunders[10] map areas, uppermost Paleozoic rocks of the Brazeau Range are known as the Rundle formation. This formation has been divided into lower, middle and upper members. The upper member is described as light colored, cherty, calcareous dolomite, which on Dizzy Creek in the Alexo map area is 347 feet thick. This member is overlain by Jurassic beds. It is believed that this member correlates to the Lower and perhaps Middle member of the Greenock formation which in the south end of the Bighorn range total 330 feet. The massive chert present in the Bighorn Range as the Middle member, is missing in the Brazeau Range, either due to erosion or facies change, probably the former.

The Rundle formation includes the thin bedded to massive limestones and thin dolomite beds which lie above the bedded Banff limestones and shales, and below the dolomite of the Greenock formation. It has been found relatively easy to correlate members of sections from north-west to south-east along strike, but difficult to reach a conclusion regarding correlation from east to west. Thus, sections 6, 7 and 9 of ranges 3 and 4 show similar units; 4, 5 and 8 of the second and first ranges are similar; and sections 1, 2 and 3 of the Bighorn Range are nearly identical. This formation is thought of as comprising four members, but in correlating these units certain facies changes have been assumed, and changes in thickness across strike disregarded.

Member 1 is the basal massive interval of light grey, coarse, most often crinoidal limestone. It varies in thickness from 12 feet in the Bighorn range to 180 in section 7 of the 4th range.

Member 2 lies above Member 1, and is an impure, dark, fine to coarse limestone, which is thin bedded to shaly, and weathers back in sections 5, 8, 7 and 9, and is massive with shaly intervals in sections 1, 2, 3 and 6. In the Bighorn range this member continues upward above Member 1, making the lower, thick, massive interval of the Rundle in that region. In section 6 Member 2 is thick bedded, with thick, thin bedded intervals. Such changes in bedding between sections are due to local conditions of deposition, and the varying argillaceous content from one place to another. The dark grey brown color of most beds in this interval indicate the impure nature of the limestone in all regions.

Member 3 is the interval above Member 2, which is characterized by dense, microcrystalline to medium crystalline, medium to dark limestone with a concentration of white to yellow calcite blebs which may make up almost 50% of the rock in some beds. Oolites are usually present in at least one bed of this member, and porous intervals are known where calcite blebs and eyes are missing or few in number. In the Bighorn range, this member occurs at the top of the lower massive interval.

Member 4 is the uppermost Rundle and includes massive to thin bedded, coarse to finely crystalline, dark limestone and dolomite, with varying porosity. Of sections 6, 7 and 9, section 9 has nearly twice the thickness of beds in this interval, with lighter massive limestone in the middle, and is very cherty in the otherwise normal rock types of the upper part. Such a change might indicate a 3-fold division of Member 4 to the south. Sections 4, 5 and 8 have more porous beds in this interval. Member 4 of sections 1, 2 and 3 is thin bedded, fine grained, easily weathering, and porous. Limestone and chert breccias,

and thin shale and dolomite beds are common in this unit in the Bighorn range.

The thickening of Member 4 in section 9 may indicate that it is this interval which thickens southward and accounts for most of the difference in thickness between the Rundle of these sections and that at Banff where it is over 2200 feet thick. The change of thickness of members in the Rundle formation is not considered due to erosion intervals. No evidence of disconformity was recognized in the field. The members are not necessarily horizons of contemporaneous deposition but represent a sequence followed throughout the region, and subject to modification by local environments.

The members defined here cannot be found in published sections of the Rundle at the type section on Tunnel Mountain near Banff (29)(2). Further detailed examination of sections over the 60 miles between Banff and section 9 of this thesis will be necessary.

The great increase in thickness of sections of the Rundle group described by Douglas (6) from southern Alberta over these is somewhat confusing, but the general lithologic sequence seems to be maintained and it is proposed to correlate Member 4 to the upper members of the Mt. Head formation, Member 3 to the Baril and Wileman members of the lower part of that formation, and Members 2 and 1 to the Livingstone formation.

The sections of the Rundle formation correlate well in thickness and lithology to those described by Brown from the Mt. Greenock area. The Rundle of sections 5 and 8 is comparable in thickness to that of section IB of the Mount Greenock area, while the Rundle of sections 6, 7 and 9 compares to that of section III A. This would be expected

considering the consistency between sections in the same thrust blocks. The members described here are present in the expected positions in sections from the Mt. Greenock area. The porosity of the upper Rundle of Brown's sections is greater than the average of Members 3 and 4 of these sections, but a trend to increased porosity northward is definitely shown by sections 5 and 4.

To the east, sections of Rundle from the Brazeau Range have been described by Crombie (5) and Erdman (10) who divided this formation into three. The upper member of that division is believed to be the Lower member of the Greenock formation. The lower member of that division seems to be units 1, 2 and 3 of the Rundle in the Bighorn range, while the middle member of that division corresponds in all respects to unit 4 of the Rundle in the Bighorn Range.

The Banff formation below the sequence concerned in this thesis, is divisible roughly into upper and lower parts. The upper is thin to thick bedded, fine to coarse, dark limestone and shale beds, the lower is very thinly bedded, alternating hard nodular limestone, and grey shale, with the shale increasing downward and occurring as pale grey green easily weathered shale in the lower 100 feet or so. The base of the upper part is marked by a thick massive limestone bed. The topmost bed of the Banff is generally dolomitic. The total thickness of the Banff varies from 550 feet in the Bighorn range to 780 feet below section 9.

DETAILED DESCRIPTION OF SECTIONS

SECTION 1, WAPIABI CREEK, BIGHORN RANGE
Pl. 3, B; Fig. 4

Spray River Formation

	Thickness Feet
Quartzite, buff grey to mauve in blotches, weathering greyish pink to rusty. Fine grained. Thin bedded to platy. Vague crossbedding.....	2
Shale, maroon, green and grey, blotchy.....	1
Covered.....	7

Greenock Formation

Upper Member missing

Middle Member

Chert and sandy chert, grey, thick bedded, poorly bedded, weathering light to dark grey.....	12
Pellet conglomerate. Pellets are chert, dolomite and collophane up to ½ in. in diameter, and well rounded. Matrix is quartzite or sandstone, light to medium brown, fine grained.....	0.5

Lower Member

Siliceous dolomite, finely crystalline to microcrystalline, hard, thin bedded to poorly bedded and massive weathering, medium grey to grey brown, weathering grey to buff. Dense but with thin porous zones. Dark chert in irregular lenses common. Fossil locality 1-7, near top of this interval.....	50

	Thickness Feet
Argillaceous dolomite, microcrystalline, hard, often porcellanous and probably siliceous, thin bedded with very thin and shaly breaks, grey to grey brown and grey green, weathers drab brown to cream. Laminated beds and slightly undulating bedding planes are present. This interval weathers back below the massive unit, appears transitional from underlying shale.....	6
Dolomitic shale, grey green to pale green, weathering yellow, with 3 feet of maroon shale near middle of interval.....	12
Argillaceous dolomite, microcrystalline, hard and brittle to firm, thin bedded and very thin bedded, light grey green and grey brown; very thin green shale breaks common. Appears transitional from massive beds below.....	20
Siliceous dolomite, finely crystalline to microcrystalline, hard, medium bedded, poorly bedded, massive weathering, light grey brown. Bands of chert lenses up to 5 inches thick, dark grey, are common. A four foot finely crystalline porous interval is present 5 feet from the base.....	30
Dolomite and argillaceous dolomite, finely crystalline to microcrystalline, hard with porous layers, thin bedded to medium bedded, well bedded, light grey brown. This interval weathers back below the massive	

	Thickness Feet
unit, appears transitional from underlying shale.....	17
Shale, dolomitic, revealed in a covered area by digging, light green, soft.....	5
Argillaceous dolomite, finely crystalline to microcrystalline, tough to brittle, thin bedded to poorly bedded, medium to light grey green to grey brown. Thin shale breaks common, and a 2 foot shale bed occurs at 6'. Shale is dolomitic, grey green. Dolomite beds grade into the shale beds. Interval rather easily weathered.....	15
Dolomite, siliceous, argillaceous and calcareous, fine to microcrystalline with calcareous phases coarsely crystalline, light to medium brown grey, medium bedded to thin bedded, generally well bedded, crosslaminated siliceous beds common, (checked by thin section). Few shale breaks are black or green shale. Calcareous beds usually porous. Chert blebs common in lower beds.....	54
Dolomite, fine to medium crystalline, thick bedded, massive weathering, (Pl. 2, B), medium grey brown, weathering drab grey brown darker than above intervals. Chert bands common from 25 to 30 feet. Fossil locality 1-6 near top of this interval, and 1-5 in basal bed.....	92
Dolomite becoming calcareous downward. A thin to thick bedded, well bedded transition interval. Dolomite is	

	Thickness Feet
fine crystalline, light grey, perhaps siliceous, becomes calcareous, medium to dark grey, fine to medium crystalline, and may have narrow porous layers near base.....	17
Total.....	330

Rundle Formation

Member 4

Argillaceous limestone, finely crystalline to microcrystalline, hard, medium to thin bedded, dark grey to black, usually a few very thin shale breaks. May include large lenses of limestone and chert breccia.....	47
Limestone, argillaceous ?, dark grey, massive. Chert breccia in lower few feet.....	20
Limestone, argillaceous ?, dark grey, thin bedded; beds of limestone breccia common, shale breaks present.....	34.5
Covered.....	5.5
Limestone, argillaceous ?, grey to dark grey thin to medium bedded. Shale in medium beds, and very thin breaks is grey. Dolomite present in thin beds. Limestone breccias present.....	23.5
Covered.....	11.5
Dolomite, silty, light grey thin bedded; calcareous black shale and dark grey dolomitic limestone, thin bedded.....	5

	Thickness Feet
Covered.....	15
Limestone, argillaceous, grey brown; dolomite calcareous, light grey finely crystalline; thin bed of grey brown, calcareous shale.....	5.5
Member 3	
Limestone, medium grey brown, fine to microcrystalline, dense, with clear calcite flecks about 1/16 inch.....	10
Covered.....	10
Dense limestone as above, medium bedded massive weathering. At 12 feet, an eight inch bed with many oolites.....	66
Limestone, medium crystalline, massive weathering, medium grey brown, with a few ostracods ?, and crinoid discs.....	12
Limestone, finely crystalline, dark brown-grey, brittle, weathering buff-grey.....	6
Limestone, finely crystalline, dark grey with many white calcite veinlets. This bed weathers out making a reentrant in the cliff face.....	6
Limestone, fine to medium crystalline, grey, fetid, massive weathering. Poorly fossiliferous.....	15
Limestone, dark grey, dense, brittle, easily weathered, calcite veined, reentrant.....	7
Limestone, brown, coarsely crystalline, crinoidal. Fossil locality 1-4.....	13

	Thickness Feet
Dolomite, slightly calcareous, finely crystalline, massive weathering, grey black to brown. Contact with overlying limestone is styolitic. Fossil locality 1-3 is 6 feet below top of this unit.....	24
Covered.....	4
Limestone, fine to medium crystalline, grey brown, becomes crinoidal and dark brown downward, massive.....	27
Member 1	
Limestone, coarsely crinoidal, light to medium grey brown, massive. Fossil locality 1-2.....	12
Total.....	380

Banff Formation

Argillaceous limestone and shale, calcareous, thin bedded, alternating with medium beds below. Fossil locality 1-1 occurs in the upper 3 feet of the Banff formation. The Banff formation was not described. The total thickness of the Banff formation is.....	580

SECTION 2, BLACKSTONE RIVER, BIGHORN RANGE
Pl. 3,A; Fig. 4

Spray River Formation

	Thickness Feet
Sandstone, medium grained to fine grained, thin bedded, grey, weathering grey brown.....	3

Greenock Formation

Thickness
Feet

Upper Member missing

Middle member

Chert and sandy chert. Sandy pockets in upper 10 feet of this unit resemble sand of overlying Spray River formation. Chert becomes gradually nearly free of sand, is light smoky grey, checked by thin section, massive..... 20

Pebble and pellet conglomerate lensing with breccia along strike. Pebbles are missing in places along strike. The pellets and the sandstone-quartzite matrix persist. Pebbles are flat, black, chert, rounded and lying parallel to bedding, with long diameter up to 2 in. Pellets are collophane (checked by thin section), chert and dolomite, black to pale yellow, usually rounded, with a diameter of up to 1/8 inch. These pellets are concentrated in vague laminations. The matrix is usually a quartzite of regrown quartz, collophane and chert, it may become greatly predominant as the pebbles and pellets become scarce in some places. The breccia which occurs in lenses at this horizon consists of angular fragments of light grey chert in seams of dark chert and quartzite. The contact of this bed with the overlying chert is gently undulating or sharply

	Thickness Feet
irregular but apparently with a relief of never more than 6 inches.....	0.7-3
Lower Member	
Silty dolomite, thick bedded, massive weathering, hard, dense, fine to microcrystalline, light brown grey. Chert is common as irregular laminations, bands and lenses which often anastamose.....	30
Dolomite, calcareous, fine to medium crystalline, porous, massive, light to medium grey-brown. Fossil locality 2-5 three feet from the top of this interval.....	14
Dolomite, siliceous, finely crystalline, hard, massive weathering, medium to dark grey brown. Chert bands and blebs common. Calcite filled vugs present. At three feet and eleven feet in this interval are discontinuous bands of chert breccia about 6 inches thick.....	16
Dolomite, argillaceous, finely crystalline to microcrystalline, often nearly porcellanous, thin bedded becoming thinner downward, few laminated beds, medium brown grey, weathering light grey-buff. Apparently a transition zone from shaly interval below..	10
Shale, dolomitic, grey to greenish with pink blotches, weathering yellow and cream. Few very thin bands of laminated argillaceous dolomite.....	7.5

	Thickness Feet
Argillaceous dolomite, microcrystalline, very thin bedded to thin bedded, light grey brown, often nearly porcellanous. Shale breaks common, up to 6 inches thick.....	25.5
Dolomite, finely crystalline to microcrystalline, hard, massive over upper half, lower half vaguely to well bedded, medium bedded, medium grey, weathering drab grey brown. Bedding contacts in lower part are often stylolitic. At base of interval a band of black chert lenses up to 2" x 15".....	34
Argillaceous dolomite, microcrystalline, often porcellanous, very thin bedded to thin bedded, light grey to brownish or greenish grey, weathering light grey buff. Shale beds up to 2 feet thick are common. Shale is dolomitic light grey green to dark grey in lower part of interval. Rarely a bed of chert breccia develops, and at 10 feet from the base of the interval, an 18 inch bed of porous calcareous dolomite. Very thin chert lenses rare.....	50
Dolomite, finely crystalline, dense to porous and vuggy, thin bedded, light grey to light brown grey. Calcite vugs aligned parallel to bedding, chert and calcite patches and bands common. Weathers grey-buff with rusty stain on some bedding planes. Lowest bed may weather to a clayey, bright yellow and red and drab	

	Thickness Feet
green calcareous mass.....	8
Dolomite and calcareous dolomite, finely crystalline, fetid, massive weathering, medium grey. Corals both single and colonial present but hard to remove. Fossil locality 2-4 in top 3' of this interval. Chert lenses, discontinuous bands of limestone breccia, calcareous vuggy porous bands, and rarely, pockets of crinoidal limestone are present in this interval.....	32
Dolomite and calcareous dolomite, finely crystalline, thin bedded, light to medium grey. Partly covered. Dense and porous beds occur. Fossil locality 2-3 is 4 feet from base of this interval.....	27
Limestone and calcareous dolomite, (patchy), fine to medium crystalline, massive, medium grey. Top foot has small pellets of calcite. Largely an interval of fragments of shells, crinoids and corals. A few preserved single and colonial corals.....	38
Limestone, thin bedded, dense, light to medium grey, fine crystalline with small clear, calcite crystals. This interval may be dolomitic. It is considered a transition interval from the Rundle formation below.....	9
Total.....	323

Rundle Formation

	Thickness Feet
Member 4	
Argillaceous limestone, dark grey to black, microcrystalline to finely crystalline, dense, thin bedded with styolitic contacts between some beds. Middle portion of beds may be lighter in color and laminated; below, light to medium grey beds become common. Calcite blebs and stringers are common. Chert and limestone breccias occur in thin beds at 2 horizons but are discontinuous along strike. Thin shale breaks are common. Gently undulating bedding planes occur.....	43
Limestone, medium brown grey, poorly bedded, calcite veins and blebs abundant. Limestone breccia occurs in pockets and thin bands. Shale intervals numerous. Calcareous dolomite and dolomite beds increase in number downward.....	31
Covered.....	28
Dolomite, argillaceous, finely crystalline, medium grey to light grey, very thin bedded to shaly.....	5
Covered.....	7
Limestone, laminated, thin bedded, medium to dark grey.	3
Covered.....	9
Dolomite and limestone, finely crystalline, thin bedded to shaly, medium to light or dark grey brown. Partly covered.....	16

	Thickness Feet
Member 3	
Limestone microcrystalline to finely crystalline, dense, massive, medium brownish grey. From $3\frac{1}{2}$ to $4\frac{1}{2}$ feet, numerous pisolites and white calcite blebs. The calcite blebs continue to the base of this unit and are very numerous. Single corals at 12'.....	13
Limestone or dolomite (varies along strike) thin bedded to shaly, dark brown-black weathering brown, fine crystalline and may have a few calcite blebs.....	4
Member 2	
Limestone dark brown, finely crystalline to medium crystalline, massive.....	11
Limestone, dark grey to black, finely crystalline, thin bedded with few shaly breaks.....	14
Limestone, dark grey, finely crystalline, massive, becomes lighter downward with darker bands, no bedding breaks until 24 feet. Few single corals.....	29
Calcareous dolomite, rubbly weathering, light brown grey, finely crystalline with calcite blebs.....	6
Dolomite, black, dense, thin bedded.....	2
Calcareous dolomite, massive.....	8
Limestone, dark brown black, finely crystalline, easily weathering and forms a reentrant.....	4
Limestone, light to medium grey, fine to medium	

	Thickness Feet
crystalline with some crinoid detritus. Weathers grey. Massive.....	8
Limestone, dark brown-grey, finely crystalline, weathering brown-grey. Massive.....	9
Limestone, medium grey, coarsely crinoidal, weathering grey. Few single corals. Fossil locality 2-2 in lower 8 feet.....	12
Limestone, dark brown, finely crystalline with black calcite crystals. Many single corals but hard to obtain, also small colonies at 17-23 feet - fossil locality 2-1.....	58
Member 1	
Limestone, light grey, medium to coarsely crystalline, crinoidal, massive, light weathering.....	15
Limestone, finely crystalline, light grey, a few coarse crystals in upper part. This bed occurs under the overhang of the massive cliff above, and is the lowest bed of the Rundle formation.....	2.5
Total.....	335

Banff Formation

Argillaceous limestone, platey medium to dark grey, fossiliferous (Top beds).	
Total.....	560

SECTION 3, CHUNGO CREEK, BIGHORN RANGE
Fig. 4

Greenock Formation

Thickness
Feet

Upper Member missing

Middle Member

Chert, light grey with sandstone pockets. Top surface of this bed is hummocky, with a relief of up to 6 inches. The Spray River formation immediately above chert is covered, 20 feet above chert the Spray River platy, siltstones are revealed.

At six feet in the chert occurs a 1 foot, sporadic, pellet conglomerate in the quartzite matrix. Sandy chert continues below to base of interval which is marked by another pellet conglomerate as described in section 2, but no pebbles or breccia were seen here..... 14

Lower Member

Dolomite, silty, finely crystalline to microcrystalline, thin bedded for 3 feet then massive, light grey brown, weathering buff. Chert blebs and bands common..... 35

Dolomite, argillaceous, microcrystalline, porcellanous, thin bedded with shale breaks, light grey green. A transitional zone from shale below..... 10

Shale, greenish brown grey, weathering rusty yellow.... 11

	Thickness Feet
Dolomite, argillaceous, microcrystalline, nearly porcellanous, light grey brown, weathering light grey buff, thin bedded with very thin green shale breaks. A one foot bed of calcareous porous dolomite near top of interval.....	14
Dolomite, siliceous, finely crystalline, grey, weathering drab grey brown. 2' porous bed at 6 ft., where calcite weathered out of vugs. Basal ten feet becomes microcrystalline and thin bedded as a transition from the shaly interval below.....	19
Argillaceous dolomite, microcrystalline, very thin bedded to thin bedded, with green shale beds up to 2' thick. Dolomite is grey green, often porcellanous. Interval weathers light buff.	14
Dolomite, argillaceous, siliceous ?, medium grey, microcrystalline, thin bedded, no shale breaks. At 2', a 3 inch white, crystalline quartz band.....	8
Dolomite, argillaceous, light grey, thin bedded, microcrystalline, weathering light buff; at top of interval is 18" of grey shale. Calcareous porous zones near base of interval.....	21
Shale, grey green, yellow weathering, with thin laminated beds of argillaceous dolomite.....	15
Dolomite, microcrystalline, dense, light grey brown,	

	Thickness Feet
weathers grey buff; becomes porous, finely crystalline and slightly calcareous by 3 feet, weathers medium grey brown below and becomes soft, dark saccharoidal, vugular, calcareous.....	21
Dolomite, thin bedded, medium brown grey, finely crystalline, porous.....	31
Dolomite, dense, calcareous, dark grey brown, thin bedded. Lithostrotion colonies and calcite vugs occur in certain beds. Fossil locality 3-2 is 3 feet below top of this interval.....	11
Calcareous dolomite, medium crystalline, thick bedded, massive weathering, mainly fragmental as at the same horizon in section 2. Small colonies and single corals present. Porous bands numerous.....	34
Dolomite and calcareous dolomite, thin bedded, finely crystalline, light brown grey with brownish and white calcite flecks in upper part. Becomes increasingly calcareous downward. A transition interval from Rundle limestone below.....	5
Total.....	280

Rundle Formation

Member 4

Argillaceous limestone, black, microcrystalline, dense, thin bedded to poorly bedded and massive weathering.

	Thickness Feet
Varies to medium brown grey. Breccia of chert about 18 inches thick at 9 feet. Bedding breaks are clean or marked by an inch or so of shale.....	23
Covered.....	11
Limestone to dolomite, medium to dark brown grey, dense to porous, thin bedded to shaly. Breccia beds common. Calcite veinlets and blebs, and shale intervals up to 2 feet thick are common.....	45
Covered.....	18
Limestone to dolomite, thin bedded, dense to porous, medium brown grey. Thin beds of breccia numerous. Laminated beds common. Undulating contacts between beds noted.....	47
Member 3	
Limestone, microcrystalline, medium brown grey, dense, with white calcite blebs common in upper 15 feet and a concentration of them with abundant pisolites at 8 feet from the top. Interval is massive, with only a few bedded intervals. Calcite eyes sparse in lower portion.....	55
Limestone, argillaceous, thin bedded, microcrystalline becoming finely crystalline downward, dark to medium brown grey. Calcite eyes present near base. Some contacts are stylolitic.....	6

	Thickness Feet
Member 2	
Limestone, black to dark grey, fine crystalline thin to thick bedded, averaging about 3 feet.....	99
Member 1	
Limestone, coarsely crystalline, crinoidal, massive, medium grey brown. Fossil locality 3-1 is on dip face at top of this unit.....	51
Total.....	355

Banff Formation

Contact of Rundle with Banff is marked by a one foot bed of dolomite, thin bedded, grey with green and reddish hue. Dark, thin, argillaceous limestone beds occur below.

Total..... 520

SECTION 4, CAIRN-MEDICINE TENT PASS, FIRST RANGE
Fig. 3

Spray River Formation

Shale and siltstone, easily weathered, make up the lowest beds of the Spray River. Above these are platy brown sandstones. Shale is approximately 30 feet thick.

Thickness
Feet

Greenock Formation

Upper Member

The Upper member of the Greenock formation may be represented here by a one foot bed of brown quartzite and sandstone, (checked by thin section), but this bed cannot be definitely excluded from the Spray River formation nor from the Middle member.

Middle Member

Chert, light blue grey, mostly pure but with some sandy pockets in upper part, massive..... 41

Sandstone, quartzitic, medium grained, brown. Contact with above chert is very irregular on a small scale in that sandstone appears to intrude into the chert for 6 or 8 inches as irregular, hooking, fingers and blobs a few inches across. There are a few chert fragments in the sandstone in some of these "intruding" bodies..... 1

Conglomerate of flat, black, phosphatic ? and cherty pebbles and small rounded pellets of the same material and dolomite, in a matrix similar to the above sandstone. A few irregular bands of red-black chert and phosphatic material ? are present. Lower contact is sharp..... 1

Lower Member

Dolomite, silty, microcrystalline to finely crystalline,

	Thickness Feet
thin bedded, light greenish and brownish grey. Chert bands up to 6 inches thick prominent at some intervals throughout.....	49
Dolomitic shale, grey.....	2
Dolomite, siliceous, microcrystalline, porcellanous, thin bedded, light to medium grey. Little chert in thin bands.....	5
Dolomite, siliceous ?, finely crystalline to microcrystalline, light to medium grey brown, weathering light grey. Chert bands common.....	19
Dolomite, porous, medium crystalline, grey. A rubbly weathering interval.....	15
Dolomite, finely crystalline, dark grey, thin bedded..	14
Dolomite, medium grey brown, poorly bedded.....	7
Covered (probably porous dolomite).....	8
Dolomite, finely crystalline, light to medium grey. Little porosity. Top 10 feet massive, thin to medium bedded below.....	17
Dolomite, finely crystalline or granular, dark to medium brown grey, thin bedded, well bedded.....	63
Dolomite, porous, grey, rubbly weathering.....	8
Dolomite, calcareous, medium crystalline, light grey, massive.....	4
Dolomite, finely crystalline, light to medium grey, thick bedded.....	6

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	Thickness Feet
Dolomite, finely crystalline or granular, dark grey, massive.....	13
Argillaceous dolomite, thin bedded to shaly, microcrystalline, porcellanous, light grey green to dark grey, weathering generally light grey.....	42
Dolomite, alternating light and dark grey, microcrystalline, thin bedded, thin chert bands.....	11
Dolomite, massive, finely crystalline, dark grey weathering brown. Little porosity as calcite blebs weather out.....	54
Dolomite, microcrystalline, thin bedded dense, medium brown grey. Partly covered.....	28
Shale, grey.....	2
Dolomite, dense, dark grey, medium bedded.....	5
Dolomite, finely crystalline, dark grey thin bedded, rubbly. Dip slopes show irregular crusts of chert. Coral colonies at 12 feet and 15 feet. Few single corals. Slight porosity at 18 feet.....	45
Shale, grey.....	2.5
Dolomite, dark grey brown, finely crystalline, soft porous beds present. Calcite blebs in some beds. Lithostrotion colonies at 1 foot. Crinoidal debris and fenestrellinids in porous beds of lower 10 feet.	57
Covered.....	20

	Thickness Feet
Dolomite dark grey to brown, porous, calcite blebs as stringers, finely crystalline.....	55
Total.....	595

Rundle Formation

Member 4

Limestone, finely crystalline, light to medium grey brown, dense, small clear calcite eyes occasionally present. Difficult to distinguish from the above dolomite without using acid. Few porous bands.....	48
Limestone, dark grey, microcrystalline, thin bedded, poorly bedded.....	6
Limestone, medium grey brown, finely crystalline to cryptocrystalline, with calcite eyes.....	19
Limestone, microcrystalline, dark grey to black, white calcite veinlets.....	4
Limestone, laminated, grey and black on weathered surface.....	2
Covered.....	82

Member 3

Limestone, microcrystalline, dense, medium grey brown with white calcite eyes. Massive.

Section discontinued due to inaccessibility of cliffs below.

SECTION 5, VALLEY HEAD MOUNTAIN, 2nd RANGE
Pl. 4, A; Fig. 3

Spray River Formation

Thickness
Feet

The contact of the Spray River formation with the underlying chert is covered. The lowest Spray River exposed is five feet above the chert and is black silty shale which extends up for about 20 feet and is overlain by brown weathering, platy siltstones and sandstones.

Greenock Formation

Upper Member missing

Middle Member

Chert, medium blue grey, sandy in patches, thick bedded, massive weathering, weathering grey brown. Basal few inches contains pebbles and patches of breccia. Contact with underlying dolomite is undulating, having up to 18 ins. relief..... 43

Lower Member

Dolomite, silty, finely crystalline to microcrystalline, well bedded, medium bedded, light grey brown. Chert present throughout, concentrated near middle of interval in lenses and lensing bands up to 8 inches thick and parallel to bedding for most part. Lower third of interval is thin bedded..... 85

	Thickness Feet
Dolomite, argillaceous, thin bedded to shaly, light grey, some beds laminated. Covered intervals common.....	28
Dolomite, siliceous, microcrystalline to finely crystalline, medium grey, well bedded, thin bedded with shale breaks up to 3 inches thick. At about 20 ft. the bedding becomes massive, the color darker and chert becomes common in blebs.....	64
Dolomite, coarse crystalline, fragmental, medium to dark grey.....	2
Dolomite, fine to medium crystalline, medium to dark grey, medium bedded.....	26
Dolomite, finely crystalline, thin bedded, few chert bands.....	48
Covered.....	52
Dolomite, microcrystalline to finely crystalline, light to medium grey.....	5
Covered.....	10
Dolomite, finely crystalline, saccharoidal, poorly preserved coral colony.....	7
Calcareous dolomite, medium crystalline, porous, thick bedded, medium brown, rubbly outcrop.....	40
Covered.....	23
Calcareous dolomite, as above.....	78
Total.....	511

	Thickness Feet
Rundle Formation	
Member 4	
Limestone, dark grey, dense, calcite blebs and vugs present near top, thick bedded, massive weathering.....	31
Dolomite, hard, dense grey, microcrystalline, reentrant.....	2
Limestone, dark grey, porous near top.....	18
Limestone, light to medium grey, finely crystalline....	3
Limestone, dark grey, massive, porous throughout.....	21
Limestone, light to medium grey brown, porous, medium crystalline or granular.....	16
Limestone, medium to fine to coarse crystalline and crinoidal, slightly porous, medium brown to grey.....	53
Limestone, light grey, soft, somewhat chalky, finely crystalline, reentrant.....	10
Member 3	
Limestone, medium crystalline, oolitic, light grey for 2 feet, becomes medium to dark grey, finely crystalline with little porosity, massive.....	8
Limestone, finely crystalline, light brown with dark blebs, thin bedded.....	2
Limestone, light grey, chalky, soft.....	3.5
Covered.....	3

	Thickness Feet
Limestone, porous, light grey-brown with pink and cream blebs, and black and white pellets and faint laminations. An easily weathering interval.....	11
Limestone and dolomite, thinly interbedded, dark to light grey, hard to soft, few beds faintly laminated.	17
Covered.....	7
Limestone, finely crystalline, dark grey to black, massive.....	10
Limestone, light grey brown, soft, thin bedded, very porous.....	5
Covered.....	25
Limestone, black, dense.....	.5
Limestone, light grey, porous, finely crystalline with dolomite bands.....	10
Member 2	
Limestone, dense, finely crystalline becoming microcrystalline downward, dark grey to light grey alternately, few wavy calcite bands and dolomite bands, well bedded, medium bedded.....	94
Argillaceous limestone, dull brown to black. Brachiopods present in scree believed to be from this interval.....	14
Limestone, dark grey, hard, dense, massive. Few single corals. Medium crystalline fragmental band at 5 ft..	19
Dolomite, dense, light to medium grey.....	3

	Thickness Feet
Limestone, dense, hard, dark grey, medium bedded, weathering brown.....	26
Limestone, coarse crystalline, dark grey, fragmental brachiopod and crinoid fragments, medium bedded. Lower ten feet massive.....	57
Dolomitic limestone and limestone, finely crystalline, thin bedded, rubbly, light to dark grey. Fossil locality 5-2 at 3 ft.....	28
Limestone, dark grey, coarse crystalline, some crinoidal debris, massive. Few fine crystalline bands.....	20
Limestone, finely crystalline, medium bedded.....	12
Member 1	
Limestone, coarse crystalline or granular, light grey, clean, crinoidal, massive.....	67
Limestone, fine to medium crystalline, light brown.....	1.5
Limestone, coarse to medium crystalline, light to medium grey brown, often crumbly.....	23
Dolomite, dense, finely crystalline, slightly calcareous, light grey brown.....	3
Limestone, coarse crystalline, medium to dark brown black (varying in color along strike) massive.....	10
Total.....	637

Banff Formation

Dolomite, dark grey, well bedded.....	5

	Thickness Feet
Limestone, argillaceous, dark grey, fine to medium crystalline, platy to thin and medium bedded, well bedded. Fossiliferous beds (locality 5-1) at 5 feet	106
Calcareous shale in nodular, thin bedded intervals alternating with massive beds of coarse to fine, dark limestone.....	75
Calcareous grey shale alternating with hard dense nodular, black argillaceous limestone in very thin beds.....	300
Shale, black, pyritic, not silty.....	32
Alternating shale and nodular limestone as above.....	75
Shale, pale grey green, fissile, mostly covered.....	80
Limestone, very hard, dark grey, microcrystalline, dense, well bedded, medium bedded. Pyritized rhynchonellids and Spirifers common.....	10
Total.....	683

Exshaw Formation

Shale, black, yellow stained, brittle, non calcareous. Contorted. Mostly covered.....	19

Palliser Formation

Limestone, dark bedded.

SECTION 6, JOB CREEK, 3rd RANGE
Pl. 4, B; Fig. 2

Spray River Formation

	Thickness Feet
Shale, silty, grey to black.....	40

Greenock Formation

Upper Member missing

Middle Member

Chert, pure, blue grey, and sandy chert, medium grey brown. A sand band at 18 ft. for 1 foot with black elliptical pellets. Sandy phases are most common in lower half. Basal 3 ins. contains black chert and light grey dolomite pebbles up to 2 ins. across, usually flat, and pellets less than 1/8 in. in a quartzite matrix.....	39

Lower Member

Dolomite, siliceous, microcrystalline, thin bedded, light brown grey to grey green, few beds up to 4" thick of green shale. Few chert blebs.....	25
Dolomite, siliceous, medium grey, thin bedded, massive weathering, many bands up to ½ in. of black chert. Laminations in much of this interval due to concentrations of quartz silt. (Checked by thin section)..	42
Dolomite, argillaceous, well bedded, thin bedded to shaly, microcrystalline to fine crystalline.....	10

	Thickness Feet
Dolomite, microcrystalline, siliceous, light grey brown, medium bedded, massive weathering, few thin bedded reentrants. Porous zones present up to 5 ft. thick in lower half.....	91
Dolomite, light grey brown, microcrystalline, chert nodules and lenses increase till at 15 ft. they account for 20% of the rock, by 70 feet, chert is scarce.....	94
Dolomite, argillaceous, platy to shaly, fine crystalline, medium grey with green and pink tinge. Lower half of interval mostly covered.....	70
Dolomite, finely crystalline to microcrystalline, hard, medium grey, much chert in top 4 ft., soft slightly porous interval from 4 to 15 feet. Four feet from base is a 1 foot bed of coarse light grey limestone with fossil fragments.....	64
Calcareous dolomite, soft, coarse, porous, massive, light brown grey, saccharoidal. Fossil fragments common.....	21
Dolomite, microcrystalline, thin bedded, dark grey, easily weathered; varies to light grey, chalky and porous.....	64
Total.....	520

	Thickness Feet
Rundle Formation	
Member 4	
Limestone, coarse, speckled, brown and white, the dark brown material varies from 40% to 75% of the whole and appears to be mainly recrystallized crinoidal debris.....	1.5
Limestone, fine crystalline, platy, light to medium grey brown with black flecks. Fenestrellinids abundant, fossil locality 6-6. Black chert blotches common.....	5
Limestone, finely crystalline, light brown; top 18 ins. porous, lower 16 ft. rather dense with much black chert in blebs.....	17.5
Limestone, coarse crystalline, fragmental, medium grey and light brown, massive; becomes slightly less coarse downward and crinoidal limestone occurs in bands.....	22
Calcareous dolomite, finely crystalline, medium grey, dense, reentrant.....	6
Limestone, coarse crystalline to medium crystalline, crinoidal, dark grey to light grey brown. Fossil fragments common.....	31
Calcareous dolomite and dolomite, thin bedded to medium bedded, light grey to medium grey, reentrant...	30

	Thickness Feet
Limestone, coarse to medium crystalline, dark grey, well bedded. Poorly preserved coral colonies in massive, basal 15 ft.....	39
(Thrust fault may have increased this thickness by 15 or 20 feet.)	
Calcareous dolomite, dense, grey, reentrant.....	4
Limestone, coarse to medium crystalline, light to medium and dark grey, medium bedded.....	20
Limestone as above, but massive; fragmental band 6 ft. thick at 20 ft., fossil locality 6-5.....	96
Calcareous dolomite, dark grey dense, medium bedded with shale breaks.....	26
Limestone, coarse crystalline, dark grey becomes less coarse downward, massive. Fossil locality 6-4 near top of this interval.....	67
Member 3	
Limestone, dolomitic ?, thin bedded, porous, light brown, reentrant.....	19
Limestone, medium crystalline, dense, dark grey with white calcite flecks.....	11
Calcareous dolomite and limestone, thick bedded. Porosity good in some beds. Oolitic bed at 20 ft.....	33
Limestone, dense, hard, finely crystalline dark blue grey, massive; becomes brownish, microcrystalline with scattered porous bands.....	39

	Thickness Feet
Limestone, dense, light grey brown, finely crystalline, reentrant.....	8
Covered.....	10
Dolomite to limestone, porous, thin bedded, light to medium grey brown, soft, lower part massive, limestone, less porous, but speckled with white and yellow flecks of calcite or clear calcite eyes which may weather out to produce porosity or may be secondary, plugging pores and small vugs. Except for spots, limestone is dense, finely crystalline, dark grey brown..... (Thickness may be increased about 30 ft. by fault).	114
Calcareous dolomite, light grey, finely crystalline, reentrant.....	5
Limestone, medium grey, finely crystalline, with small calcite flecks, massive.....	35
Member 2	
Limestone, dark grey, bedded reentrant.....	10
Limestone, finely crystalline, dark grey as above but massive.....	30
Dolomite, black, dense, finely crystalline, thin bedded to platy.....	26
Limestone, fine, crystalline, light to medium grey, hard, massive, dense with few clear calcite eyes. At 15 feet, have black cherty, cryptocrystalline	

	Thickness Feet
blebs which are lensing and may anastamose. Fossil locality 6-3 at 27 ft. in a bedded interval. Limestone becomes dark grey downward and coarse crystalline near the base.....	92
Limestone to dolomite, platy to medium bedded, light grey, fine to coarse crystalline. Fossil locality 6-2 in this interval.....	22
Limestone, thick bedded, medium grey, medium crystalline.....	20
Limestone, dark grey, finely crystalline, to medium brown grey, coarse crystalline, with dark grey weathering, thin, microcrystalline bands. Thick bedded to massive. Fossil locality 6-1 in this interval...	104
Member 1	
Limestone, coarse crystalline, often crinoidal, light grey, weathering light grey, often porous.....	102
Total.....	1043

Banff Formation

Argillaceous limestone, fossiliferous, medium bedded intervals alternating with massive beds of fine crystalline black limestone.....	63
Calcareous shale thinly alternating with dense, hard, black, nodular limestone in intervals which alternate with massive, medium crystalline dark, limestone intervals.....	146

	Thickness Feet
Shale and nodular limestone thinly alternating shale gradually becoming predominant downwards.....	470
Shale, green-brown, mostly covered.....	11
Total.....	690

Exshaw Formation

Shale, black, brittle, non calcareous, stained yellow and orange..... 25

Palliser Formation

Limestone, dark grey, finely crystalline, cherty bedded

SECTION 7, HEADWATERS OF CORAL CREEK, 4th RANGE
Pl. 5 ; Fig. 2

Spray River Formation

Shale, silty, black; actual line of contact not exposed.

Greenock Formation

Upper Member missing

Middle Member

Chert, black, thick bedded, with white quartz stringers near top. Upper dip face is gently rolling. Lower 5 feet has sandstone pockets and weathers grey, yellow and red. Basal 4 inches is nodular, soft, iron stained..... 30

	Thickness Feet
Lower Member	
Chert and quartzite; thin section shows chert to be mainly sponge spicules, and quartzite to be overgrown clastic quartz and carbonate, with a carbonate matrix. Hand specimen is light grey with black patches. Quartzite predominates in lower foot.....	2
Dolomitic sandstone, medium grey brown, fine grained detrital quartz in carbonate cement. (Checked by thin section). Sand decreases downward. Interval is well bedded, thin bedded with occasional very thin breaks and some laminations. Slight porosity in a few beds.....	38
Dolomite, siliceous, finely crystalline, medium brown grey, thin bedded, easily weathering, partly covered.	12
Dolomite, cryptocrystalline, light brown grey, thin bedded. Top 20 ft. with many lenticular chert bands. Lower part partly covered.....	140
Dolomite as above, medium to thick bedded, massive weathering. Much chert.....	25
Dolomite, light grey brown, massive, porous.....	10
Dolomite, light to medium grey brown, microcrystalline to fine crystalline, medium to thin bedded, well bedded, rather massive weathering. Few coarse crystalline brown dolomite beds up to 4 ins.....	43

	Thickness Feet
Dolomite, microcrystalline, thin bedded, light grey cream, soft.....	15
Dolomite, fine crystalline to microcrystalline, light to medium grey brown, medium to thin bedded, well bedded.....	115
Dolomite, fine crystalline, light grey, rubbly weathering, well bedded as above.....	10
Dolomite, bedded, massive weathering with chert in bands and blebs.....	20
Dolomite, medium crystalline to coarse crystalline and crinoidal, medium brown grey, thick bedded, massive weathering, chert blebs common, little porosity; becomes fine crystalline, light grey, massive.....	40
Dolomite, light grey, soft, slightly porous, homogeneous, mottled with white and medium grey spots. Reentrant.....	10
Dolomite, light grey brown, medium to coarse crystalline, often crinoidal, rather porous; becomes soft and chalky, finely crystalline below 3 feet.....	25
Covered.....	65
Total.....	600

Rundle Formation

Member 4

Limestone, finely crystalline, brown, platy soft, fossiliferous (Lithostrotion colony), with chert

	Thickness Feet
nodules.....	2
Limestone, medium to coarse crystalline, often crinoidal, massive, medium grey brown to black; becomes finer crystalline with bands of crinoidal ls. below. Dolomitic reentrants at 25 feet for 5 feet and at 70 ft. for 7 ft.....	93
Dolomite, soft, porous, light grey; fossil locality 7-5	2
Limestone, medium to coarse crystalline, crinoidal, medium grey brown in medium to thick massive beds, alternating with medium beds of easier weathering dolomite or calcareous dolomite, hard, brittle, fine crystalline dark grey.....	53
Limestone, crinoidal, oolitic, fossiliferous, massive.	9
Dolomite, calcareous light grey, fine crystalline, laminated.....	8
Limestone, coarse crystalline, often crinoidal, medium brown.....	20
Dolomite, fine crystalline thin bedded, with 4 feet of bedded medium crystalline brown limestone near middle.....	11
Limestone, coarse to medium crystalline often crinoidal, medium to dark grey brown, massive.....	50
Covered (Dolomitic reentrant).....	10
Limestone, medium crystalline, partly crinoidal, dark grey brown, massive.....	60

	Thickness Feet
Dolomite, fine crystalline, light grey, laminated.....	10
Member 3	
Limestone, microcrystalline, medium grey brown with calcite blebs.....	6
Covered.....	2
Limestone, fine crystalline, saccharoidal light to medium brown, porous, massive.....	32
Limestone, microcrystalline, medium grey brown with white and yellow calcite flecks massive.....	20
Dolomite reentrant.....	2
Limestone as above but with fine crystalline beds, fewer calcite flecks, some clear calcite eyes, thick bedded.....	14
Limestone, fine crystalline, medium grey brown, medium to thick bedded.....app.	30
Member 2	
Limestone, thin bedded to shaly, dark, medium crystalline. Fossil locality 7-4.....app.	20
Limestone, medium bedded, well bedded, dark brown, coarse crystalline, crinoidal.....app.	30
Argillaceous limestone, thin bedded to shaly. Fossil locality 7-3.....app.	30
Covered (possibly faulted).....	170
Limestone, medium grey, mottled, coarse crystalline, rubbly weathering.....	15

	Thickness Feet
Limestone, coarse crystalline, medium bedded to platy when argillaceous. Bryozoan and crinoid remains common.....	45
Shale, light buff grey weathering.....	10
Limestone, medium to coarse crystalline medium brown grey, medium bedded to platy, fossiliferous. Mostly covered. Fossil locality 7-1 in basal 18 feet.....	60
Covered.....	5
Limestone, medium to thick bedded, massive dark to medium brown grey, coarse crystalline, crinoidal.....	30
Argillaceous limestone, thin bedded and platy, partly covered.....	5
Limestone as above.....	20
Limestone medium bedded, well bedded, otherwise as above.....	30
Limestone, fine to medium crystalline, dense, hard, medium grey with much dark chert in lenses along bedding planes and crusty patches on dip slopes.....	5
Member 1	
Limestone, light grey brown, coarse crystalline, often crinoidal, soft to firm, massive. Basal 5 ft. is dark brown, medium crystalline with few crinoid remains.....	180
Total.....	989

Thickness
Feet

Banff Formation

Dolomite, medium brown-grey, dense, fine crystalline.. 1.5

Limestone, medium brown, coarse crystalline, crinoidal in spots, well bedded, medium bedded.

Total thickness unknown.

SECTION 8, SASKATCHEWAN RIVER, 2nd ? RANGE
Fig. 3

Spray River Formation

Siltstone, laminations wavy, thin bedded to platy, weathering brown.

Covered.....app. 20

Argillite, silty, laminated, black.....app. 20

Covered..... 30

Greenock Formation

Upper Member

Quartzite and quartz sandstone, grey brown medium bedded, massive weathering..... 20

Quartzite with leached patches giving hand specimen brecciated appearance. Massive, light to medium grey brown, fine grained (Checked by thin section).. 10

Sandstone and quartzite ?, medium brown grey, hard, thin bedded, becoming poorly bedded and massive downward. Chert pockets in lower 10 feet..... 25

	Thickness Feet
Middle Member	
Chert, light to medium grey blue, massive, much sandstone in upper part as contact with Upper Member is gradational. Nearly pure for 25 ft. near middle, then sandy to base where chert is black and sandstone pockets are brown.....	75
Quartzite, mauve-grey, massive.....	2.5
Pebble conglomerate; pebbles black, matrix grey sandstone. Weathering rusty.....	0.5
Lower Member	
Sandstone with black chert pockets weathering brown.....	2
Sandstone fine grained, pinkish grey, massive, blue grey weathering.....	2
Silty or sandy dolomite in undulating contact with above ss. Relief up to 3 ft. Chert bands common in dolomite.....	3
Silty dolomite, fine crystalline to cryptocrystalline, medium brown grey to dark brown, massive.....	9
Sandstone, dark brown.....	1
Covered.....	1
Silty dolomite, thin bedded with shaly breaks, microcrystalline, light grey brown.....	5
Covered.....	3
Dolomite, siliceous, light grey brown, fine crystalline, laminated, bedded as above.....	17

	Thickness Feet
Covered.....	3
Dolomite, siliceous ?, thin bedded to poorly bedded and massive, microcrystalline, light to medium grey brown. Slightly porous near top.....	30
Dolomite, thin bedded, partly covered.....	13
Dolomite, siliceous ?, medium blue grey to light brown grey, thick bedded, weathering light grey.....	31
Dolomite as above, microcrystalline to fine crystalline, thin bedded.....	18
Dolomite, siliceous, dark to medium blue to brown grey, massive. Much chert in small blebs and cherty lenses..	19
Dolomite basal bed of above cliff, medium brown grey with many white calcite flecks or good porosity.....	3
Dolomite, thin bedded, dark grey to medium grey brown, fine to microcrystalline, bedding breaks are straight, stylolitic or shaly. Very little chert. Becoming thinner bedded downward and platy near base.....	71
Dolomite, siliceous ?, medium brown grey, fine to microcrystalline, thick bedded. Chert abundant from 20 to 30 feet as fine laminations, and present in rest of interval as scattered blebs. Lower 15 ft. massive.....	65
Covered.....	9
Dolomite, thick bedded, massive weathering dark grey, fine to microcrystalline.....	25
Dolomite medium grey brown, thin bedded and laminated	

	Thickness Feet
but massive weathering.....	14
Dolomite dark blue grey, fine crystalline, reentrant, thin bedded.....	5
Covered.....	5
Dolomite, dark blue grey, thin bedded.....	10
Dolomite, dark blue grey, thin bedded with chert bands and blebs and finely laminated beds.....	20
Covered.....	8
Dolomite, medium blue grey, thin bedded to platy, badly fractured, no chert.....	5
Dolomite dark grey with much chert, thin bedded.....	12
Dolomite, fine crystalline dense, medium to dark grey, massive, top 5 ft. vaguely laminated. Chert blebs common.....	21
Dolomite, dark grey, medium crystalline with coarse phases, vuggy porosity, massive.....	8
Dolomite, dense, fine to medium crystalline.....	4
Limestone, medium to coarse crystalline, crinoid and coral fragments and cup corals, medium grey, massive.....	3
Dolomite dark grey, dense, fine crystalline massive.....	4
Covered.....	18
Total.....	600

Rundle Formation

Member 4

Limestone, medium to coarse crystalline, dark grey, thin

[illegible]

[illegible] .... [illegible]

[illegible]

[illegible] .... [illegible]

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[illegible]

	Thickness Feet
bedded. Fossil locality 8-8.....	3
Dolomite, thin bedded, medium to dark grey.....	3
Limestone light to medium grey, top foot black, fine to medium crystalline. Few vuggy bands. Some bands crinoidal. Fossil locality 8-7.....	11
Dolomite, fine crystalline, light grey.....	1
Limestone, fine to medium crystalline, medium to dark grey, dense, hard, medium bedded. Blebs of dense white clayey material. Slight porosity. Small Syringopora colonies common.....	10
Limestone, medium to coarse crystalline, softer, medium grey, thin bedded, massive weathering, slight porosity	10
Covered.....	3
Limestone, light to dark grey, fine to coarse crystalline, thin bedded to massive; some beds fossiliferous and crinoidal, some with clear calcite eyes. Fossil locality 8-6 in middle ten feet.....	31
Dolomite and calcareous dolomite, fine crystalline, thin to poorly bedded, light grey, reentrant.....	7
Limestone, dark grey, fine crystalline, massive.....	7

Member 3

Limestone, light to medium brown, fine to microcrystalline, thick bedded, massive weathering. White calcite flecks up to 1/2 in. common, abundant in some beds.

	Thickness Feet
Vuggy porosity common where calcite missing. Two foot dolomite reentrant at 38 feet.....	116
Limestone, medium brown grey, very thin to thick bedded, well bedded.....	20
Covered.....app.	55
Limestone and dolomite, thinly interbedded, light to dark grey, fine crystalline.....	5
Limestone, medium brown to black with few white calcite flecks, fine crystalline, thin bedded.....	5
Limestone, microcrystalline, medium grey brown, thick bedded, massive weathering. Calcite flecks abundant for the most part, concentrated in bands parallel to bedding.....	60
Member 2	
Dolomite, fine crystalline, partly calcareous, dense, light to medium grey, reentrant.....	5
Limestone, thick bedded, medium grey.....	8
Limestone, fine crystalline with a few medium crystalline fragments, dark grey, thin bedded to platy, with siliceous nodules.....	22
Limestone, fine crystalline matrix with black crinoid ? fragments up to 1/8 in., unbedded, few single corals, reentrant.....	20
Covered.....	17
Limestone black, fine to medium crystalline massive.....	5

	Thickness Feet
Covered	5
Limestone, medium to coarse crystalline, dark grey, well bedded, with a ten foot massive bed near middle	25
Covered	3
Limestone, medium crystalline, medium to dark grey or light grey with dark fragments. Few vugs. Massive	9
Limestone, medium crystalline dark grey, to fine crystalline light grey, with dark fragments and crystals of medium grain size. Thin bedded. Fossil locality 8-8	18
Dolomitic limestone, light grey, fine crystalline, thin bedded	3
Limestone, fine to coarse crystalline, thin bedded, dark grey to medium grey, as dark, coarse particles decrease. Fossil locality 8-4	16
Limestone, fine crystalline, medium grey with many coarse dark calcite grains or crystals, massive. Fossil loc. 8-3 at base	12
Dolomite, calcareous, fine to medium crystalline, medium grey brown, thin bedded	2
Limestone, thin to medium bedded, light grey fine crystalline with coarse dark calcite particles, and some coarse crystalline beds. Many black chert blebs and irregular bands in lower 10 feet	28

	Thickness Feet
Member 1	
Limestone, light grey, coarse crystalline crinoidal, with medium and fine crystalline phases, massive, thick bedded in upper 40 feet. Contact with underlying Banff is sharp gently undulating. Fossil locality 8-2.....	152
Total.....	697

Banff Formation

Dolomite with calcareous phases, fine crystalline, light to medium grey, medium bedded. Fossil locality 8-1...	4
Limestone, medium bedded with thin platy breaks. Fossil fragments common.....app.	30

Total thickness unknown.

SECTION 9, HEADWATERS SOUTH RAM RIVER, 3rd RANGE
Pl. 6, Fig. 2

Spray River Formation

Shale, black, silty for 50 ft. overlain by grey brown, thin bedded siltstone. Line of contact of shale and chert is covered.

Greenock Formation

Upper Member missing

Middle Member

	Thickness Feet
Chert, massive, dark to medium blue grey, with calcite stringers and blebs at top, pure to sandy.....	39
Lower Member	
Quartzite and chert, dolomitic, thick bedded, medium grey, mottled, hard, very fine grained (less than 0.1 m m.), (checked by thin section). Becomes slightly porous near base, where rock is silty dolomite, (30% insoluble).....	14
Silty dolomite, as above but carbonate seems consistently prevalent.....	42
Chert, massive, dark blue grey, interbedded with dark dolomitic quartzite. Contact with above dolomite is irregularly undulating with 5 in. relief.....	16
Silty dolomite with many thin bands of black chert; thin bedded to nodular and poorly bedded; dolomite is grey to black and may be platy.....	41
Silty dolomite (23% insoluble materials, mainly quartz) thin bedded well bedded, light to medium grey, siltyness seems to vary. Narrow beds of white chert near base.....	11
Quartzite, dolomitic, (22% soluble), with few dark grains.....	5
Dolomite, granular, silty, fine grained, porous.....	15
Dolomite,(98% soluble), granular, light grey brown, fine grained, thick bedded, massive weathering,	

	Thickness Feet
coarser and porous with dark stain near middle.....	59
Silty dolomite, medium to light grey and pinkish, chert lenses common. Lophophylum ? in sandstone band at 15 ft.; loc. 9-3.....	20
Dolomite, fine to medium crystalline, thick bedded, light grey-buff, porous.....	35
Dolomite, light grey, fine crystalline dense, thin to thick bedded, massive interval, silty and laminated siliceous beds common. Dark chert lenses common in some silty beds.....	50
Dolomite, medium brown, slightly calcareous, soft, slight porosity, a thin bedded reentrant with 4 ft. hard dolomite in middle.....	10
Limestone, soft, dense, light grey brown, thin bedded, few laminations.....	10
Dolomitic limestone, fine crystalline, medium brown grey, thinly interbedded with dark grey dolomite and laminated siliceous dolomite.....	17
Dolomite, medium blue grey to light brown, fine crystalline, dense, thin bedded. Bedding planes sharp, straight or stylolitic. Cross laminations abundant, may indicate siltyness.....	33
Calcareous dolomite, medium brown, slightly porous, many calcite flecks, massive.....	6
Dolomite, medium bedded, brittle, dense, massive weathering, light brown grey.....	14

	Thickness Feet
Calcareous dolomite, dark blue grey fine crystalline, medium bedded. Becomes dolomite downward, and chert bands are abundant near base.....	13
Total.....	450

Rundle Formation

Member 4

Limestone, medium to dark grey, medium crystalline with fine and coarse crystalline beds, thin to thick bedded. Light grey, dense dolomite and light grey coarse limestone bands rare. Chert in blebs and bands common throughout.....	104
Limestone, coarse crystalline, light to medium grey brown, poorly bedded, mostly covered.....	50
Dolomite, fine crystalline, light grey, thin bedded. Chert bands frequent.....	10
Covered.....	20
Limestone, light to medium grey, dense, fine crystalline, chert abundant in bands and blebs. Poorly thin bedded, partly covered.....	33
Limestone, medium to fine and coarse crystalline, often crinoidal, light to medium grey brown, continuously massive.....	50
Covered.....	15
Limestone, very porous, fine crystalline, massive.....	28

	Thickness Feet
Limestone, dense, dark to medium grey, fine crystalline, thin bedded to massive alternately. Chert blebs common.....	62
Limestone medium to fine or coarsely crystalline, occasionally crinoidal, light to medium brown, thick bedded but bedding indistinct, massive weathering. Some chert near top.....	190
(This interval uncommon in Member 4 in other sections)	
Limestone as above but dark grey.....	50
Calcareous dolomite, nodular, thin bedded.....	4
Limestone, light to medium grey brown, crinoidal.....	1
Calcareous dolomite as above.....	6
Limestone, medium to coarse crystalline medium grey, medium bedded, massive weathering. Upper 10 feet has thin beds of fine crystalline limestone and fossil locality 9-2.....	98
Limestone, thin bedded, poorly bedded, fine crystalline, dark grey.....	8
Dolomite, dense, medium grey, thin bedded, fine crystalline.....	10
Member 3	
Limestone, microcrystalline to fine crystalline, light to medium grey brown, massive, much white calcite in blebs from 10 feet down.....	41
Dolomitic limestone reentrant.....	4

	Thickness Feet
Limestone as above, fewer calcite blebs and these only in some beds. Porosity poor. Massive.....	44
Limestone dark grey, fine to medium crystalline, thick bedded.....	20
Member 2	
Limestone, dark, medium crystalline thin bedded, alternating with thin beds of argillaceous limestone with platy to shaly habit. Fossil locality 9-1 near top...	154
Limestone, as above, but fewer shaly beds, becoming massive downward, chert blebs present, increasing downward.....	46
Limestone, dark to medium grey, poorly thin bedded, chert blebs and bands abundant, reentrant.....	29
Covered.....	5
Member 1	
Limestone, light to medium brown, medium crystalline with coarse phases, massive, chert common at top.....	25
Limestone medium to dark grey, medium crystalline.....	4
Limestone, poorly bedded, nodular, light to medium grey, fine crystalline. Black chert lenses abundant. This and above interval make reentrant in cliff of Member 1 such as is unknown in other sections.....	25
Limestone, light to medium brown, medium crystalline with coarse phases. Very porous, soft, somewhat chalky, from 42 to 55 (app.) feet. Basal 10 feet	

	Thickness Feet
becomes gradually dark brown grey but remains coarse.	78
Total.....	1214

Banff Formation

Dolomite, fine crystalline, dark grey thin bedded to poorly bedded.....	3-6
Limestone, thin to thick bedded, with interbedded shale beds, shale increasing downwards.....	124
Limestone, massive, dark grey, fine crystalline, with shaly reentrant at 40 ft.....	60
Limestone, dark, fine crystalline, lensing, very thinly interbedded with shale, a few medium beds of crinoidal limestone.....	300
Limestone thin bedded with shale interbeds, shale increasing downward.....	160
Shale, grey green, with thick beds of black shale.....	130
Total.....	780
Exshaw Formation.....	33
Palliser Formation.....	

CHAPTER II

STRATIGRAPHIC PALEONTOLOGY

Faunal Assemblages

Upper Part of the Banff Formation

The following list comprises the total fauna collected from the uppermost beds of the Banff formation of sections 1, 5 and 8. No collections were made from the Banff in other sections.

Camarotoechia
C. metallica (White)
C. tuta (Miller
Cleiothyridina lata Shimer
Composita humilis (Girty)
C. humilis var. A n. var.
C. immatura (Girty)
Dictyoclostus arcuatus (Hall)
D. cf. jasperensis (Warren)
Dielasma cf. chouteauensis Weller
Greenockia sp. A
Linoproductus ovatus (Hall)
Platyrachella rutherfordi (Warren)
Punctospirifer solidirostris (White)
Rhipidomella tenuicostata Weller
Spirifer albertensis Warren
S. cf. minnewankensis (Shimer)
S. missouriensis Swallow
Torynifer cf. pseudolineata (Hall)

This fauna indicates a correlation to Kinderhook time. Torynifer pseudolineata is a Keokuk form and may indicate a tendency of these beds to be later than Kinderhook time, but the identification of this species is doubtful. Camarotoechia tuta is a Chouteau (upper Kinderhook) to Burlington form and together with C. metallica, Rhipidomella tenuicostata, Dictyoclostus arcuatus, Dielasma chouteauensis, Spirifer missouriensis, Composita immatura and Punctospirifer solidirostris, indicates a middle

to upper Kinderhookian correlation. Punctospirifer solidirostris, Composita humilis, C. immatura and Camarotoechia metallica give a correlation to the Madison of Montana. C. immatura occurs only in the lower bed of that formation. Dictyoclostus jasperensis and Spirifer albertensis are typical Banff fossils in the Canadian Rocky Mountains. Greenockia sp. A. has affinities to G. snaringensis Brown (3) from the upper Banff in the Mt. Greenock area. Platyrachella rutherfordi, and Cleiothyridina lata occur in the upper Banff and lower Rundle. Spirifer cf. minnewankensis is closely allied to an unidentified species of Spirifer illustrated by Girty (11) from the middle portion of the Madison limestone.

FAUNAL LISTS OF LOCATIONS IN THE RUNDLE AND GREENOCK FORMATIONS

The following locations may be found marked on the stratigraphic sections, figures 2, 3 and 4.

SECTION 1

Location 1-3
Spirifer sp. indet.

Location 1-4
Spirifer cf. minnewankensis Shimer

Location 1-5
Indet. colonial and single corals

Location 1-6
Indet. horn corals.
Syringopora cf. aculeata Girty

Location 1-7
Lithostrotion (Diphyphyllum) mutabile Kelly
Syringopora cf. aculeata Girty

SECTION 2

Location 2-1
cf. Pleurodictyum
Syringopora cf. aculeata Girty
Indet. cup corals.

Location 2-2
Pleurodictyum sp.
cf. Triplophyllites
cf. Hapsiphyllum (21)
Indet. streptelasmacean (Moore)

Location 2-3
Lithostrotion (Diphyphyllum) mutabile Kelly

Location 2-4
Lithostrotion (Diphyphyllum) mutabile Kelly
Syringopora cf. aculeata
Indet. streptelasmaceans (Moore)
cf. Triplophyllites

Location 2-5
Triplophyllites sp.
Indet. streptelasmaceans (Moore)

SECTION 3

Location 3-1
cf. Hapsiphyllum
Indet. streptelasmaceans (Moore)

Location 3-2
Lithostrotion (Diphyphyllum) mutabile Kelly

Location 3-3
Indet., coarse, angular ribbed Spirifer

SECTION 5

Location 5-2
cf. Caninia

SECTION 6

Location 6-1
Spirifer cf. minnewankensis Shimer

Location 6-2

Triplophyllites sp.
Brachythyris chouteauensis Weller
cf. Buxtonia setigera (Hall)
Chonetes sp.
Cleiothyridina cf. tenuilineata (Rowley)
Composita humilis (Girty)
C. humilis var. A n. var
Dictyoclostus gallatinensis (Girty)
D. parviformis (Girty)
D. sedaliensis (Weller)
Greenockia sp. B
Greenockia sp. D
Platyrachella sp.
Rhipidomella tenuicostata Weller
Rhipidomella cf. thiemei (White)
Spirifer minnewankensis Shimer

Location 6-3

Spirifer centronatus Winchell
Spirifer minnewankensis Shimer

Location 6-4

Indet. horn coral.

Location 6-5

Spirifer cf. minnewankensis Shimer

Location 6-6

Fenestrellina spp.

SECTION 7

Location 7-1

Pentremites sp. indet.
Composita cf. athabaskensis Warren
Composita humilis (Girty)
Rhipidomella tenuicostata Weller
Spirifer minnewankensis Shimer
Torynifer cf. pseudolineata (Hall)

Location 7-3

Composita cf. athabaskensis Warren
Composita humilis cf. var. A n. var.
Dictyoclostus sedaliensis (Weller)
Greenockia sp. B
Spirifer minnewankensis Shimer
Spirifer cf. minnewankensis Shimer
Torynifer cf. pseudolineata (Hall)

Location 7-4

Cliothyridina lata Shimer
Composita humilis (Girty)
Composita humilis cf. var. A n. var.
cf. Marginicinctus
Platyrachella sp.
Spirifer minnewankensis Shimer
Spirifer cf. minnewankensis Shimer
Spirifer cf. missouriensis Swallow

Location 7-5

Pentremites sp. indet.
Fenestrellina sp. indet.

SECTION 8

Location 8-2

Triplophyllites sp.

Location 8-3

Syringopora sp. indet.

Location 8-4

Indet. streptelasmacean
Fenestrellina spp.
Rhombopora spp.

Location 8-5

Syringopora cf. aculeata Girty
Spirifer minnewankensis Shimer

Location 8-6

Syringopora sp. indet.
cf. Ekvasophyllum (23)
Indet streptelasmaceans (Moore)

Location 8-7

Syringopora cf. aculeata Girty

Location 8-8

Syringopora cf. surcularia Girty
Indet. streptelasmacean (Moore)

SECTION 9

Location 9-1

Avonia cf. indianensis (Hall)
Cleiothyridina lata Shimer

Composita humilis (Girty)
Composita trinuclea (Hall)
Dictyoclostus gallatinensis (Girty)
Dictyoclostus cf. jasperensis Warren
Dictyoclostus parviformis (Girty)
Greenockia sp. B
Greenockia sp. C
Punctospirifer cf. subtexta (White)
Spirifer centronatus Winchell
Spirifer minnewankensis Shimer
Spiriferella cf. minnewankensis Shimer
Indet. small rhynchonellids

Location 9-2
Indet. horn coral

Location 9-3
cf. Lophophyllum

SIGNIFICANCE OF FAUNA

The sections may be divided into three groups on the basis of the ease of lithologic correlation: group 1, sections 6, 7 and 9; group 2, sections 4 ?, 5 and 8; and group 3, sections 1, 2 and 3.

Fauna from locations which appear to be at the same horizon within a group of sections are combined in the following lists in an attempt to determine the age of the Rundle and Greenock formations.

GROUP 1: Sections 6, 7 and 9 (3rd and 4th range) (Fig. 2)

Location 6-1 is the lowest fossil location of these sections. The only identifiable specimen from this location is a poorly preserved Spirifer referred to S. minnewankensis which Shimer [25] and Brown [3] report from the lower Rundle.

The fauna from locations 6-2, 6-3, 7-1, 9-1 which are considered to fall within the same interval, is as follows:

Triplophyllites sp.
Pentremites sp. indet
Avonia cf. indianensis (Hall)
Brachythyris chouteauensis Weller
cf. Buxtonia setigera (Hall)
Chonetes sp.
Cleiothyridina lata Shimer
C. cf. tenuilineata (Rowley)
Composita cf. athabaskensis Warren
C. humilis (Girty)
C. humilis var. A n. var.
C. trinuclea (Hall)
Dictyoclostus gallatinensis (Girty)
D. cf. jasperensis Warren
D. parviformis (Girty)
D. sedaliensis Weller
Greenockia sp. B
G. sp. C.
G. sp. D.
Platyrachella sp.
Punctospirifer cf. subtexta (White)
Rhipidomella tenuicostata Weller
R. cf. thiemei (White)
Spirifer centronatus Winchell
S. minnewankensis Shimer
Spiriferella cf. minnewankensis Shimer
Torynifer cf. pseudolineata (Hall)

The genera Triplophyllites and Pentremites are apparently not distinctive of any particular part of Mississippian time.

The following brachiopods occur in the Kinderhook of the Mississippi valley area: Brachythyris chouteauensis, Cleiothyridina tenuilineata, Dictyoclostus sedaliensis, Punctospirifer subtexta, Rhipidomella tenuicostata, Rhipidomella thiemei. Those found in Osage strata are: Buxtonia setigera, Cleiothyridina tenuilineata, Spiriferella, Punctospirifer subtexta, Torynifer pseudolineata. Avonia indianensis and Composita trinuclea are known in the Salem formation of the Meramec group.

Madison forms are present in Composita humilis, Dictyoclostus gallatinensis, Dictyoclostus parviformis and Spirifer centronatus.

Of those forms originally described from the lower Rundle in the Rockies of Canada the following are present: Spirifer minnewankensis, Platyrachella sp. (aff. "cf. Platyrachella rutherfordi")[3], Spiriferella minnewankensis and Cleiothyridina lata which ranges through the upper Banff and lower Rundle. Composita athabaskensis and Dictyoclostus jasperensis are upper Banff species, but are not definitely identified.

Greenockia sp. B has strong affinities with a Burlington ? form, Rhynchopora altiplicata Hyde[14].

This fauna corresponds best to that of Brown's[3] from the lower Rundle which he called the Composita esplanadensis faunule and which he suggested might be upper Kinderhookian. The presence of Osage and Meramec forms here indicate a somewhat later correlation.

Warren[29] reported a small fauna from the lower Rundle containing Spirifer centronatus and Torynifer pseudolineata in common with this fauna and associated with Spirifer logani of Keokuk time.

Shimer[25] reported the following to be most abundant in the lower Rundle, Dictyoclostus gallatinensis, Spirifer centronatus, Spiriferella minnewankensis, Cleiothyridina lata and Composita humilis, and suggested an Osage correlation.

Locations 6-4, 6-5, 7-3 and 7-4 and 9-2 are from a correlable interval. The fauna listed below is that of locations 6-5, 7-3 and 7-4 as locations 6-4 and 9-2 yielded indeterminate horn corals only.

Cleiothyridina lata Shimer
Composita cf. athabaskensis Warren
C. humilis Girty
C. humilis var. A n. var.
Dictyoclostus sedaliensis (Weller)

Greenockia sp. B.
cf. Marginicinctus
Platyrachella sp.
Spirifer minnewankensis Shimer
Spirifer cf. minnewankensis Shimer
Spirifer cf. missouriensis Swallow
Torynifer cf. pseudolineata (Hall)

This list differs from the former mainly in being less complete. Spirifer cf. minnewankensis is closely allied to S. minnewankensis of Brown and occurs with that form. Spirifer cf. missouriensis is probably a new species. The genus Marginicinctus is reported (28) to occur in the Keokuk and St. Louis horizons but its presence here is indefinite.

Locations 6-6 and 7-5 are both near the Rundle-Greenock boundary. The fauna from these locations is of little significance, consisting of indeterminate Fenestrellinas and Pentremites.

The uppermost locality in this group of sections is 9-3. At this horizon a few poorly preserved corals which have been referred to Lophophyllum were found. Lophophyllum was reported from beds of the upper Rundle at Banff which were correlated to Chester time by Warren (29).

GROUP 2: Sections 5 and 8 (2nd range) (Fig. 3)

Location 8-2, yielded single cup corals which have been assigned to the genus Triplophyllites. Distinction of species of this genus may prove helpful in zoning, but attempts at species identification here were unsuccessful.

Locations 5-2, 8-3, 8-4 and 8-5 yielded the following:

cf. Caninia
Syringopora cf. aculeata Girty
Fenestrellina spp.
Rhombopora spp.
Spirifer minnewankensis

Spirifer minnewankensis correlates this interval to the lower part of the Rundle formation of other workers. The other forms merely indicate a Mississippian age.

Locations 8-6, 8-7 and 8-8 from the upper part of the Rundle, contain the following:

cf. Ekvasophyllum
Syringopora cf. aculeata Girty
Syringopora cf. surcularia Girty
Indet. streptelasmaceans.

Ekvasophyllum is reported from the Brazer formation of Utah (23). It is not known whether this genus is restricted to the upper Mississippian. Syringopora aculeata is a middle and upper Madison form, but ranges throughout the upper Rundle and Greenock formations. Syringopora surcularia is known in the upper Rundle at Banff (29) associated with Chesterian forms.

GROUP 3: Sections 1, 2 and 3 (Bighorn Range) (Fig. 4)

Locations 1-3, 1-4, 2-1, 2-2, 3-1:

cf. Hapsiphyllum s.l.
cf. Triplophyllites
Pleurodictyum sp.
Syringopora cf. aculeata Girty
Indet. streptelasmaceans
Spirifer cf. minnewankensis Shimer

The identification of single corals is too unreliable to merit an attempt to correlate with them. Their abundance in the lowermost Rundle of these sections surpasses that at any other horizon or in the sections of the Rockies proper. Pleurodictyum is apparently restricted to this interval and is rather common in small colonies. It most closely resembles Michelina placenta as figured by Girty (11) although only about 3/4 the

size of his specimen which occurs in the basal bed of the Madison formation. This form was described by White (11) from the top of the Chouteau (Kinderhook) in Missouri.

Syringopora cf. aculeata ranges from this lowermost Rundle to the uppermost beds of the Lower member of the Greenock formation in these sections.

The Spirifer here referred to S. minnewankensis is not the widely divergent form, but a poorly preserved specimen resembling Brown's (3) figures closely. This Spirifer appears typical of the lower part of the Rundle formation.

Locations 1-5, 1-6, 2-3, 2-4, 3-2:

cf. Triplophyllites
Lithostrotion (Diphyphyllum) mutabile Kelly (19)
Syringopora cf. aculeata Girty

The Lithostrotion assigned to Kelly's (15) species agrees exactly with his specimens but, in some corallites, the columella appears continuous. Diphyphyllum is considered a genomorph of Lithostrotion, as shown by McLaren and Sutherland (19). Kelly found this species in the Mountain Park area in the upper beds of the Rundle formation near the contact with the Spray River shale. It is not known whether the horizon from which Kelly collected his holotype is actually in the Lower member of the Greenock formation or the upper Rundle of this report. This species is restricted to the Lower member of the Greenock formation in the Bighorn Range. Kelly states that this species is present in the Brazer formation of Montana.

Locations 1-7, 2-5, 3-3.

Triplophyllites sp.
Lithostrotion (Diphyphyllum) mutabile Kelly
Syringopora cf. aculeata Girty

At locality 3-3 a very poor internal mold of half of a valve of a Spirifer was found. This specimen merits mention only because it is the only brachiopod found in the Lower member of the Greenock formation. It is a medium sized form with rather coarse, angular costae resembling S. bifurcatus Hall of the Salem formation as illustrated by Weller (31).

The genus Triplophylites is apparently long ranging in Mississippian strata. Lithostrotion (Diphyphyllum) mutabile is quite likely typical of the Lower member of the Greenock formation and may indicate a correlation to Brazer time. Syringopora cf. aculeata is long ranging.

CONCLUSIONS

The foregoing indicates that Members one and two of the Rundle formation are Madison equivalents or Kinderhookian to Osagian in age, and that Member four of the Rundle formation and the Lower member of the Greenock formation have affinities to the Brazer formation of Utah, and may therefore be upper Mississippian.

Brown (3) has correlated the lower part of the Rundle formation to the Tournaisian stage (lower Mississippian) of Europe, and the Lower member of the Greenock formation to the Visean stage (upper Mississippian) of Europe. The abundance of Lithostrotion (Diphyphyllum) mutabile Kelly in the Lower member of the Greenock formation in the Bighorn Range may indicate a condition similar to that in Britain, where the base of the Upper Avonian (upper Mississippian and approximately Visean) is defined by the entrance of the genus Lithostrotion. Lithostrotion is known in the

upper part of the Rundle formation in the Banff area, and is present to a limited degree in Member 4 of the Rundle in sections from the Rockies-proper in this thesis. The lack of paleontological evidence in the Greenock formation in sections in the Rockies-proper makes it impossible to establish a time-line from east to west. Future investigation may show the presence of a regressive overlap from east to west, if the species of Lithostrotion from Member 4 in the Rockies prove to be those found in the Lower member of the Greenock formation in the Bighorn Range. If such is the case, and Lithostrotion (Diphyphyllum) mutabile Kelly (which Kelly (15) reports to occur in the Brazer formation of Utah) occurs below the Greenock in the Rockies, the age of the Greenock there will be restricted to late Mississippian or higher. The presence of the genus Lithostrotion in itself indicates Meramec age for Member 4 of the Rundle (29). The occurrence of Lophophyllum? in the Greenock formation in section 9, suggests at least a late Mississippian age for the Lower member of the Greenock.

Brown has shown the Lower member of the Greenock to be Meramec in age in the Mt. Greenock area. Warren has shown the Rocky Mountain formation to be largely Pennsylvanian in the Banff area. As these formations are one and the same, in regard to position in the section, an exhaustive search for fossils in the Greenock formation of the region concerned in this thesis would be expected to yield faunas ranging from lower Chesterian or Meramecian in the north, up to late Chesterian or Pennsylvanian in the south. Such evidence will be required before a trans-time or diachronic nature can be proven for the Greenock or Rocky Mountain formation. However, in view of the lithological nature and

consistency of position in the sequence, such a condition seems quite evident at the present time.

Fig. 2
(Legend on fig. 4)

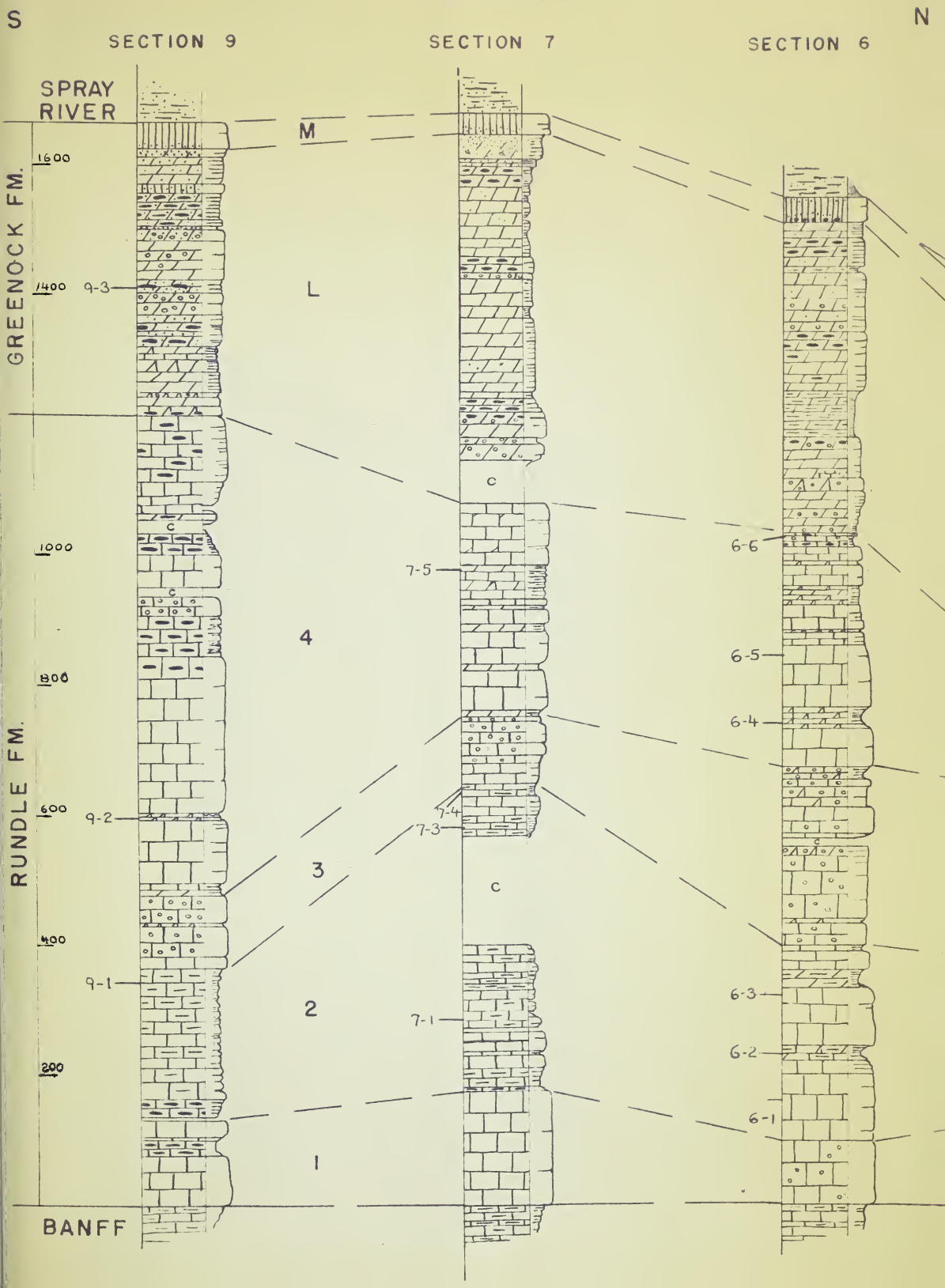


Fig. 3
(Legend on fig. 4)

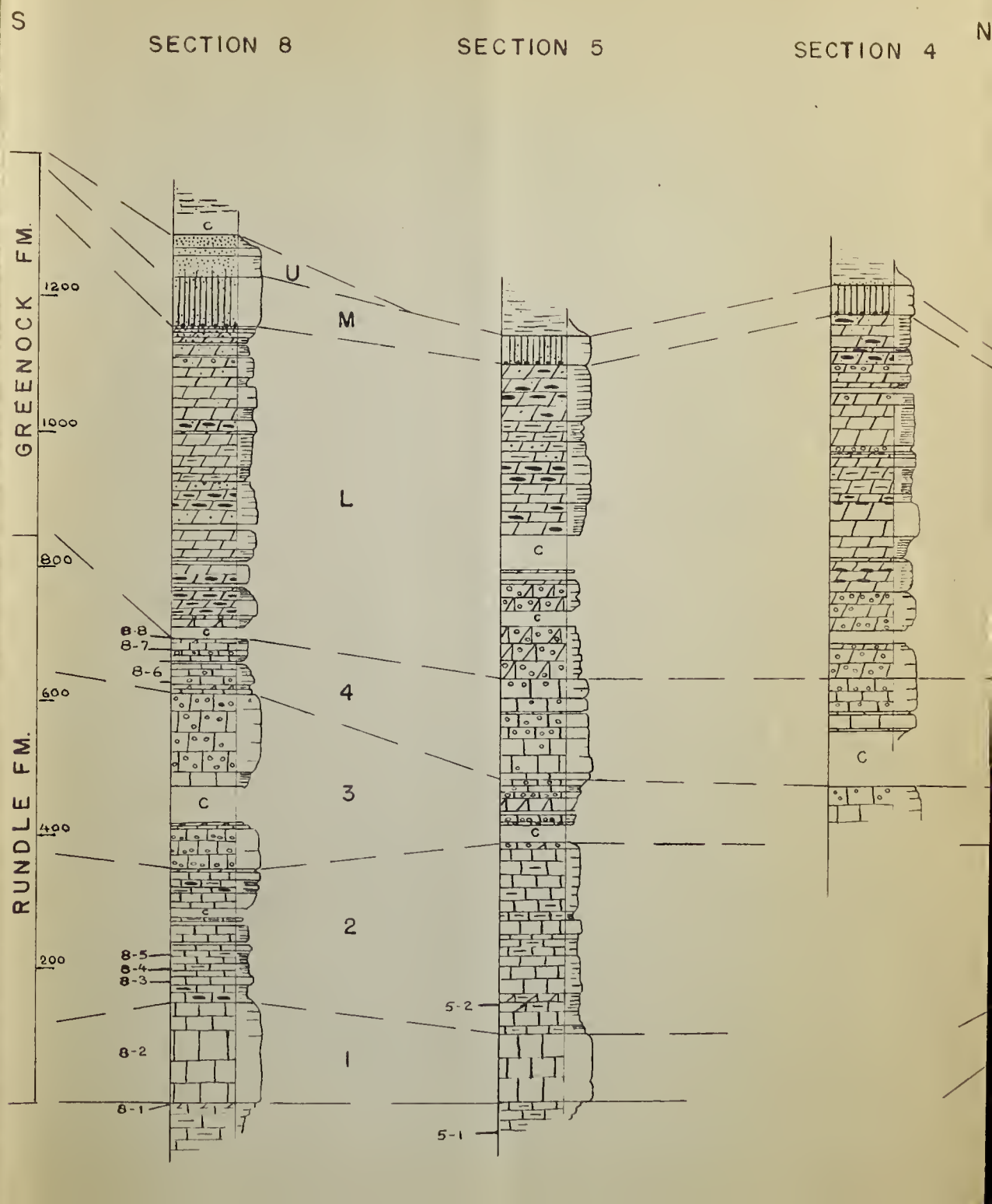
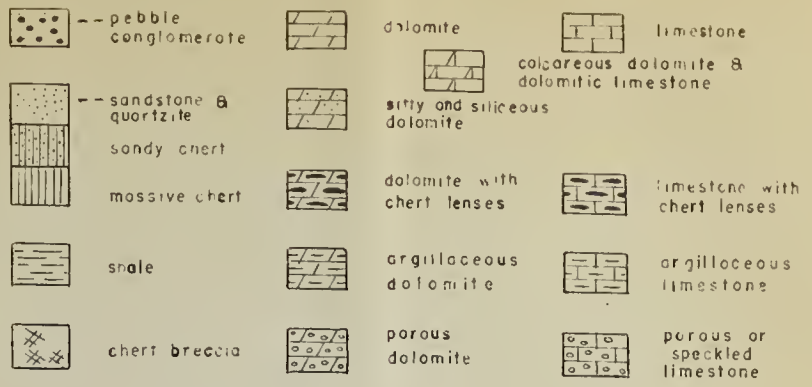
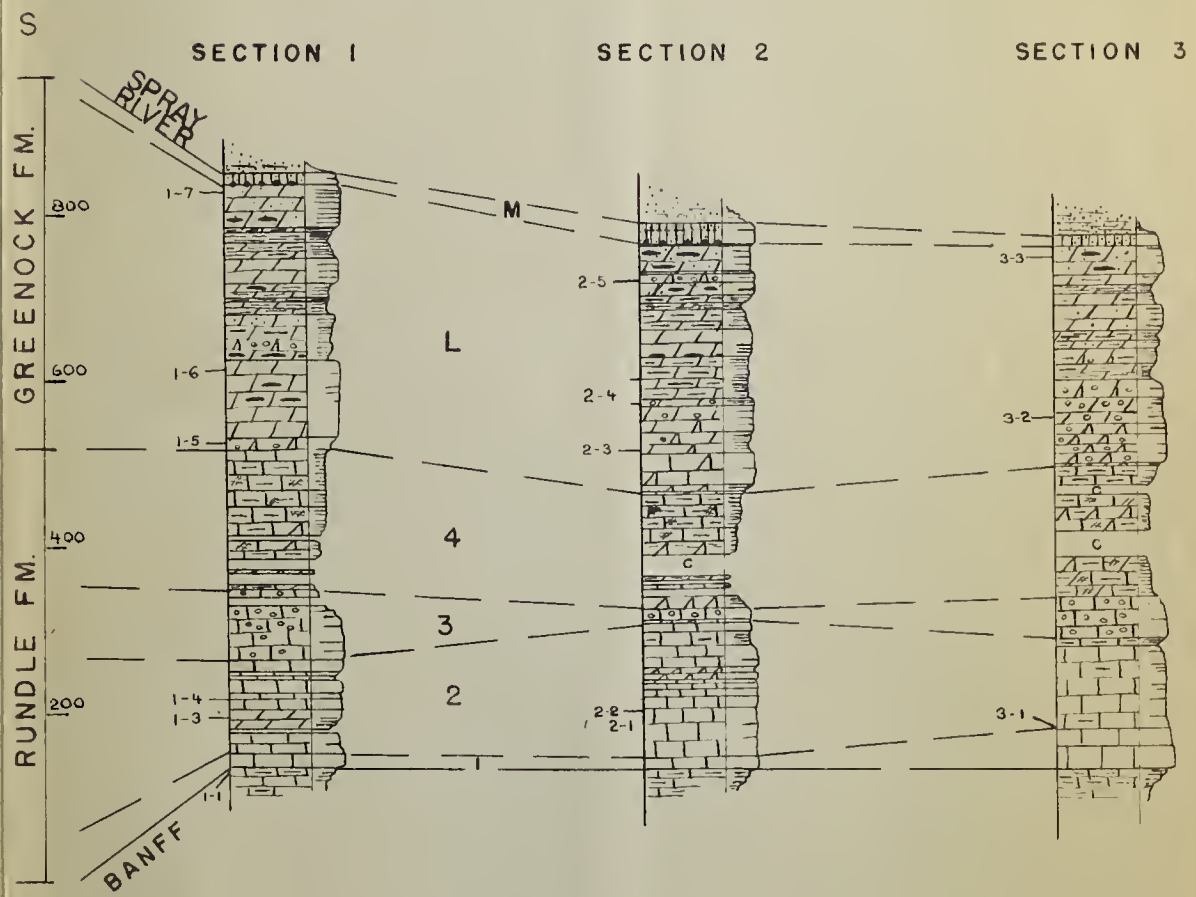


Fig. 4

LEGEND


pebble conglomerate
sandstone & quartzite
sandy chert
massive chert
shale
chert breccia
dolomite
limestone
calcareous dolomite & dolomitic limestone
silty and siliceous dolomite
dolomite with chert lenses
limestone with chert lenses
argillaceous dolomite
argillaceous limestone
porous dolomite
porous or speckled limestone


S
N
SECTION 1
SECTION 2
SECTION 3
SPRAY RIVER
GREENOCK FM.
RUNDLE FM.
BANFF
800
600
400
200
1-7
1-6
1-5
1-4
1-3
1-2
1-1
M
L
4
3
2
1
2-5
2-4
2-3
2-2
2-1
3-3
3-2
3-1
C

CHAPTER III

— SYSTEMATIC PALEONTOLOGY —

DESCRIPTION OF CARBONIFEROUS BRACHIOPODS

Classification Table

Order, Protremata Beecher, 1891

Superfamily, Orthacea Walcott & Schuchert, 1908

Family, Rhipidomellidae Schuchert, 1913

Genus, RHIPIDOMELLA Oehlert, 1890
Rhipidomella tenuicostata Weller, 1914
Rhipidomella cf. *thiemei* (White), 1880

Superfamily, Strophomenacea Schuchert, 1896

Family, Chonetidae Hall & Clarke, 1895

Genus, CHONETES Fischer, 1837
Chonetes sp.

Family, Productidae Gray, 1840

Subfamily, Productinae Waagen, 1884

Genus, AVONIA Thomas, 1914
(emend. Muir-Wood, 1928)
Avonia cf. *indianensis* (Hall), 1856

Genus, BUXTONIA Thomas, 1914
(emend. Muir-Wood, 1928)
cf. *Buxtonia setigera* (Hall), 1858

Genus, DICTYOCLOSTUS Muir-Wood, 1930
Dictyoclostus arcuatus (Hall), 1858
Dictyoclostus gallatinensis (Girty), 1899
Dictyoclostus cf. *jasperensis* Warren, 1932
Dictyoclostus sedaliensis (Weller), 1914

Genus, LINOPRODUCTUS Chao, 1927
Linoproductus ovatus (Hall), 1858

Genus, MARGINICINCTUS Sutton, 1938
cf. *Marginicinctus*

Order, TELOTREMATA Beecher, 1891

Superfamily, Rhynchonellacea Schuchert, 1896

Family, Camarotoechiidae Schuchert, 1929

Subfamily, Camarotoechiinae Schuchert, 1929

Genus, CAMAROTOECHIA Hall & Clarke, 1893
Camarotoechia metallica (White), 1914
Camarotoechia tuta (Miller), 1881

Genus, GREENOCKIA Brown, 1952
Greenockia sp. A
Greenockia sp. B
Greenockia sp. C
Greenockia sp. D

Superfamily, Terebratulacea Waagen, 1883

Family, Dielasmatidae Schuchert, 1913

Genus, DIELASMA King, 1847
Dielasma cf. chouteauensis Weller, 1914

Superfamily, Spiriferacea Waagen, 1883

Family, Spiriferidae King, 1846

Subfamily, Spiriferinae Schuchert, 1913

Genus, PLATYRACHELLA Fenton & Fenton, 1924
Platyrachella rutherfordi (Warren), 1932
Platyrachella sp.

Genus, SPIRIFER Sowerby, 1815
Spirifer albertensis Warren, 1932
Spirifer centronatus Winchell, 1875
Spirifer minnewankensis Shimer, 1926
Spirifer missouriensis Swallow, 1860
Spirifer cf. missouriensis Swallow, 1860

Genus, BRACHYTHYRIS McCoy, 1844
Brachythyris chouteauensis Weller, 1914

Genus, SPIRIFERELLA Chernuishev
Spiriferella minnewankensis Shimer, 1926

Subfamily, Reticulariinae Waagen, 1883

Genus, TORYNIFER Hall & Clarke, 1895
Torynifer cf. *pseudolineata* (Hall)

Subfamily, Spiriferininae Schuchert & LeVene, 1929

Genus, PUNCTOSPIRIFER North, 1929
Punctospirifer solidirostris (White)

Superfamily, Rostrospiracea Schuchert & LeVene, 1929

Family, Athyridae Phillips, 1841

Subfamily, Athyrinae Waagen, 1883

Genus, CLEIOTHYRIDINA Buckman, 1906
Cleiothyridina lata Shimer, 1926
Cleiothyridina cf. *tenuilineata* (Rowley), 1900

Genus, COMPOSITA Brown, 1849
Composita cf. *athabaskensis* Warren, 1932
Composita humilis (Girty), 1899
Composita humilis var. *A* n. var.
Composita immatura (Girty), 1899
Composita trinuclea (Hall), 1856

DESCRIPTION OF SPECIES

Genus, RHIPIDOMELLA Oehlert, 1890

Rhipidomella tenuicostata Weller

1914, Rhipidomella tenuicostata Weller, Mon. Ill. State Geol. Surv. vol. 1, p. 158, Pl.XX, Figs. 27-29

Remarks. Specimens assigned to this species include one pedicle valve, two brachial valves and two imperfectly preserved complete forms. The radial ornament is not preserved on all specimens, and where present lacks the spine bases described by Weller. However, the appearance and dimensions are nearly identical to Weller's figures.

Occurrence. Uppermost bed of Banff fm.; localities 1-1, 8-1. Member 2 of the Rundle fm. of sections 6 and 7; localities 6-2, 6-3, 7-1. Chouteau ls., Missouri.

Rhipidomella cf. thiemei (White)

1880, Orthis thiemei White, Contr. to Pal., No. 8, p. 164, Pl. 41, figs. 4a-d.

1904, Rhipidomella thiemei Girty, U.S.G.S., Prof. Paper No. 21, p. 48, Pl. 10, figs. 1-2.

1914, Rhipidomella thiemei Weller, Mon. Ill. State Surv., vol. 1, p. 155, Pl. 21, figs. 8-27.

Remarks. One brachial valve in a rather well preserved condition is assigned to this species on the basis of external features which appear identical with Weller's cotypes.

Occurrence. Member 2 of the Rundle fm. of section six; locality 6-2. Kinderhook of Iowa.

Genus, CHONETES Fischer, 1837

Chonetes sp.
Pl. 7, Figs. 1,2

Description. This description is based on an internal cast and the corresponding interior of a brachial valve, and an internal cast of a smaller pedicle valve.

The pedicle valve measures 9 mm. wide by $5\frac{1}{2}$ mm. long. It is subsemielliptical, widest across hinge-line. Lateral margins nearly straight, then rounding evenly into the anterior margin, which tends to straighten across its mid portion. (This outline resembles C. multicostata and C. chesterensis). The umbo is low but distinct and gently convex longitudinally and transversely. Valve nearly flat towards anterior and lateral margins. Flanks from side of umbo to posterior gently concave. Beak small. Sinus obsolete. Ornament of this interior mold consists of 82 radial costae, 6 per mm., with wider intercostae furrows which are markedly pitted towards anterior and lateral margins, and only sparingly so near the posterior margin and in the areas of muscle scars. (This condition was reported by Weller in C. shumardanus). The costae increase by bifurcation. Very faint concentric lines, 10 per mm. occur over much of the surface, most prominently near the posterior margin.

The brachial valve measures 15 mm. wide by 9 mm. long, and has the same outline as the pedicle valve. It is shallowly concave, and has flattened posterio-lateral regions. Fold nearly obsolete, present as a broad, very shallow, depressed area in the anterior third of the interior of the brachial valve. The ornament of the interior of the brachial valve consists of 112 radial costae, 4 to 5 per mm. at the margin, and 85,

5 to 6 per mm., across a perimeter corresponding to the size of the pedicle valve described. The costae of this interior side are made up of rows of pustules 3 or 4 per mm., present over the surface except for a 2 mm. margin across the posterior. This margin has minute (10 per mm.) concentric lines which cross costae and inter-costae furrows, alike.

Remarks. This specimen resembles C. chesterensis Weller most closely in outline and convexity. In size, the forms figured by Weller lie about half way between the above described brachial and pedicle valves. At a size corresponding to Weller's figures, the frequency, 5 per mm., and total number, 105, agree with Weller's findings. However, the pustulose interior was not described by Weller, and as no external features were observed on these valves, the species cannot be assigned to C. chesterensis with much assurance.

Occurrence. Member 2 of the Rundle fm. of section 6; locality 6-2.

Genus, AVONIA Thomas, 1914
(emend. Muir-Wood, 1928)

Avonia cf. indianensis (Hall) 1856
Pl. 7, figs. 3-7

1856, Productus indianensis Hall, Trans. Albany Inst., vol. 1, p. 47.

1914, Productus indianensis, Weller, Mon. Ill. State Geol. Surv., vol. 1, p. 131, Pl. 28, figs. 7-10; Pl. 83, figs. 12-13.

1938, Avonia ? indianensis, Sutton, J. of Pal., vol. 12, No. 6, p. 565, Pl. 62, figs. 7, 8.

Description. The pedicle valves assigned to this species range in size from 4 mm. by 4 mm. to 8 mm. long by 7 mm. wide. The brachial valves from 4 mm. by 4 mm. to 7 mm. long by 8 mm. wide. No one specimen retains both valves.

The pedicle valves appear identical in outline and convexity to those figured by Weller and by Sutton. The auriculations are seldom preserved, but when present show the hinge line to be narrower than the maximum width. Small spine bases are sparsely spread over most of the shell and concentrated on the aurical areas. Concentric growth lines are fine becoming slightly coarser on the anterior portion. Unlike any reported forms of A. indianensis, these valves show fairly distinct radial costae from the umbonal area forward, about 9 occurring in 3 mm. The costae are low rounded and interrupted occasionally by a concentration of growth lines which form slight wrinkles.

The brachial valves are believed to belong to the same species as the above pedicle valves, as no other Productids of comparable size were found in the same bed. The interior of the brachial valves are shallowly to moderately convex and have small, definite, flat to somewhat recurved auricular portions. The hinge-lines are slightly narrower than the widest part of the valves. Longitudinally, these valves are nearly uniformly curved, or the visceral and trail regions are well differentiated by a rather rapid bend. Only the interior surfaces of these valves were observed, the ornament on which is essentially as on the pedicle valves. The spine bases are slightly larger but of the same frequency, but not concentrated on the auricular areas. The posterior is marked by fine concentric wrinkles only. Radial costae begin in the visceral region as elongate ridges, which become continuous toward the anterior. They are of equal weight and frequency to those on the pedicle valves.

Remarks. These forms have not strong enough concentric ornament to be A. concentrica (Hall), but do resemble the forms of that species illustrated by Girty (1915) ( ) . They resemble no other species as closely as A. indianensis, and Sutton foresaw the possibility of radial ornament occurring on this species. Nevertheless, because of this difference in ornament, assignment to this species cannot be definite.

Occurrence. Member 2 of Rundle fm. of Section 9; loc. 9-1. Salem ls. Indiana.

Genus, BUXTONIA Thomas, 1914
(emend. Muir-Wood, 1928)

cf. Buxtonia setigera (Hall), 1858

1858, Productus setigera, Hall, Geol. Iowa, vol. 1, Pl. 2, p. 638, Pl. 19, fig. 3.

1914, P. setigera, Weller, Ill. Geol. Survey, Mon. 1, p. 122, Pl. 12, figs. 1-3.

1938, Buxtonia setigera, Sutton, J. of Pal., Vol. 12, p. 564.

Remarks. One incomplete pedicle valve is referred to this species as the convexity both longitudinally and transversely is more nearly that of Weller's figures than anything else seen, and the ornament is of the same nature and weight. The aurical portions are broken off. The growth lines are more prominent than those in Weller's figures.

Occurrence. Member 2 of Rundle fm. of section 6; locality 6-2. Keokuk ls. Iowa.

Genus, DICTYOCLOSTUS Muir-Wood, 1930

Dictyoclostus arcuatus (Hall), 1858

1858, Productus arcuatus Hall, Geol. Iowa No. 1, pt. 2, p. 518, pl. 7, figs. 4a-b.

1914, P. arcuatus Weller, Mon. Ill. State Geol. Surv., p. 107, pl. 13, figs. 1-12.

1938, Dictyoclostus arcuatus Sutton, J. of Pal., Vol. 12, p. 562.

Remarks. Three exfoliated but otherwise well preserved pedicle valves compare very well with Weller's figures.

Occurrence. Upper Banff (50' below Rundle ls.) in section 5; locality 5-1. Kinderhook oolite, Iowa; Chouteau ls., Missouri.

Dictyoclostus cf. jasperensis (Warren) 1932

1932, Productus jasperensis Warren, Trans. Roy, Soc., Canada, sec. IV, 3rd ser., vol. 26, p. 243, pl. 1, figs. 1-6.

Remarks. Three brachial valves compare closely with those figured by Warren. Two have slightly coarser radial ornament.

Occurrence. Top beds of the Banff fm. in section 1; loc. 1-1. Member 2 of Rundle fm. in section 9; loc. 9-1. Banff fm., Jasper area.

Dictyoclostus sedaliensis (Weller) 1914
Pl. 7, figs. 8-11

1914, Productus sedaliensis Weller, Mon. Ill. State Geol. Surv., p. 108, pl. 14, figs. 1-7.

1938, Dictyoclostus sedaliensis Sutton, J. of Pal. vol. 12, p. 563.

Remarks. One shell with posterior 3/4 of pedicle valve and posterior 2/3 of brachial valve very well preserved, and an interior of a pedicle valve are nearly identical with Weller's figs. 3, 4 and 6.

Occurrence. Member 2 of Rundle fm. of sections 6 and 7; locs. 6-2 and 7-3. Chouteau ls. Missouri.

Dictyoclostus gallatinensis (Girty), 1899

1899, Productus gallatinensis Girty, Mon. U.S.G.S. vol. 32, pt. 2, p. 533, pl. 68, figs. 7a-c.

1938, Linoproductus altonensis Sutton, J. of Pal., vol. 12, p. 558.

1952, Dictyoclostus gallatinensis Brown, G.S.C. Mem 264 p. 87.

Remarks. Forms from two localities are very similar to Girty's figs. 7a-c of D. gallatinensis but slightly smaller. They have identical longitudinal outline but are not flattened transversely across the top to the same extent.

Occurrence. Member 2 of the Rundle fm. of sections 6 and 9; locs. 6-2 and 9-1. Madison ls. (beds 25, 26 and 27) Montana.

Dictyoclostus parviformis (Girty), 1899

1899, Productus parviformis Girty, Mon. U.S.G.S. vol. 32, pt. 2, p. 536, pl. 68, figs. 6a-c.

1938, Dictyoclostus parviformis Sutton, J. of Pal., vol. 12, p. 564.

Remarks. The forms assigned to this species were found at the same localities as D. gallatinensis and may be varieties of that species. They differ in that they are smaller and are relatively shorter from the tip of the beak to the point of maximum curvature over the umbonal area of the pedicle valve. They resemble Girty's figures very closely.

Occurrence. Member 2 of the Rundle fm. of sections 6 and 9; locs. 6-2 and 9-1. Madison ls. (bed 25, 30, 31) Montana.

Genus, LINOPRODUCTUS Chao, 1927

Linoproductus ovatus Hall, 1858

1858, Productus ovatus Hall, Geol. Iowa, vol. 1, pt. 2, p. 674, pl. 24, fig. 1.

1914, Productus ovatus Weller, Mon. Ill. State Geol. Surv., vol. 1, p. 132, pl. 16, figs. 1-15.

1938, Linoproductus ovatus Sutton, J. of Pal., vol. 12, p. 558, pl. 65, figs. 8-13.

Remarks. The pedicle valve assigned here is well preserved and, except that it is smaller (20 mm. long by 18 mm. wide), is identical with Weller's figures.

Occurrence. Top beds of Banff fm., section 1; loc. 1-1. Widely ranging in Mississippian of the United States.

Genus MARGINICINCTUS Prout, 1857

cf. Marginicinctus

Remarks. One poorly preserved, very flat brachial valve seems to fall into this genus. It resembles forms figured by Weller (31) as Productus wortheni which was included in the genus Marginicinctus by Sutton (28).

Occurrence. Member 2 Rundle fm. of section 7; loc. 7-4. The genus Marginicintus occurs in the Keokuk and St. Louis fms. (Sutton).

Genus, CAMAROTOECHIA Hall and Clarke, 1893

Camarotoechia metallica (White) 1874

1874, Rhynchonella metallica White, Wheeler's Expl. and Surv. W. 100th Merid. Prelim Rept., p. 20. White, 1875:Ibid. Final Rept., vol. IV, p. 129, pl. 10, figs. 10a-b.

1877, Rhynchonella pustulosa ? Hall and Whitefield, Kings U.S. Geol. Expl. 40th Par., Vol. 4, p. 257, pl. 4, figs. 12-14.

1899, Camarotoechia metallica Girty, U.S. Geol. Surv., Mon. 32, p. 540, pl. 69, figs. 3a-e.

Remarks. These specimens have 18 to 20 plications on the flanks and four and 5 on the sinus and fold. They differ slightly from Girty's figures in being a little longer proportionately and having slightly finer costae.

Occurrence. Upper beds of the Banff fm. of sections 1 and 8; locs. 1-1 and 8-1. Chouteau formation in Missouri. Lower beds of the Madison fm., Montana.

Camarotoechia tuta (Miller), 1881

1881, Rhynchonella tuta Miller, Jour. Cinn. Soc. Nat. Hist., vol. 4, p. 315, pl. 7, figs. 11-116.

1914, Camarotoechia tuta Weller, Mon. Ill. State Geol. Surv., vol. 1, p. 179, pl. 14, figs. 9-28.

Remarks. The specimen referred to this species is a small shell resembling Weller's fig. 26 in outline. The beak is strongly incurved. Fifteen subangular, rather coarse plications ornament the shell, six on the flanks, three on the sinus and fold.

Occurrence. Top bed of Banff fm. of section 8, loc. 8-1. Chouteau and lower Burlington ls. of Missouri.

Genus, GREENOCKIA Brown, 1952

Forms assigned to this genus include two groups, those which resemble Greenockia in external features, and those whose internal features suggest Greenockia rather than other genera checked.

Greenockia sp. A

Pl. 7, figs. 12-16

Description. Valves sub-equally convex, sub-elliptical transversely and longitudinally. Longer than wide.

Pedicle valve moderately convex with greatest convexity over area posterior to umbo. Outline sub-oval, with greatest width slightly anterior to mid length. Beak strong, protruding behind brachial valve, well incurved. Sinus begins a little posterior of mid length, is flat, shallow, but well defined by abrupt flanks of bordering plications. It is produced beyond anterior margin of flanks a little. Ornament consists of simple, uniform, rounded plications, with narrow angular interspaces, 9 to 12 on each flank, and 4 to 6 in the sinus, which may be slightly closer and finer than the 3 or 4 on the flanks neighboring the sinus. Dental lamellae are present but apparently weak. Brachial valve, except for the fold, is moderately and uniformly convex. Outline sub-elliptical. Beak covered by pedicle beak. Antero-lateral flanks near margins approaching normality to plane of commissure. Fold begins at mid length, is low, flat, but well defined, especially at anterior. Ornament of brachial valve same as on pedicle valve with one more plication on fold than on sinus, and commonly one less on each flank. Interior not known.

Shell substance impunctate.

Dimensions.

Length of pedical valve	Length of brachial valve	Width	Depth
10.5	9.5	9.4	6.5
11.5	10.8	10.3	7.6

Remarks. These shells are a good deal smaller than G. snaringensis, but resemble Brown's figures 2 e and 2 f of that species.

Occurrence. Top bed of Banff fm. of section 1.

Greenockia sp. B

Pl. 2, figs. 1-12; Pl. 7, figs. 17-27

The forms described here are almost identical to Weller's (31) figures of Allorhynchus acutiplicatum, and fit Hyde's (14) description of Rhynchopora altiplicata. They are assigned to Greenockia Brown, because they are impunctate and have at least partially continuous hinge plates.

Description. Valves unequal, pedicle valve gently convex with flattened anterior flanks, brachial valve moderatly convex. Inequality increasing with maturity. Costate throughout. Impunctate.

Pedicle valve moderately convex transversely over beak becoming gradually less convex anteriorly to mid length where sinus begins. Sinus is nearly flat across the bottom, bounded by steep flanks of bounding plications. Lateral anterior flanks of valve sloping gently outward, nearly flat across top of plications. Longitudinally, pedicle valve is gently and uniformly convex from beak to anterior edge of sinus; nearly flat or slightly irregular from umbonal area to anterior along top of boundary plications. Outline of valve is subtrigonal. Posterio-lateral margins straight to gently concave near beak, maximum width about two-thirds of the way from posterior to anterior. Anterior margin broadly and evenly rounded. Beak erect, protuberant, pointed, only slightly incurved. Pseudocardinal areas small, marked, account for slightly concave anterio-lateral margin. Ornament consists of simple, rather coarse, acutely angular costae with sharply rounded crests. Exceedingly fine concentric lines are sometimes preserved. Usually 8 plications occur on each flank and 3 in the sinus.

When 4 occur in the sinus one is crowded up onto the wall of the sinus. The sinus is deep and sharply defined at the anterior margin. Internally this valve has well developed dental lamellae, (Pl. 2, figs. 1-12).

The brachial valve is moderately to deeply convex transversely throughout, interrupted in anterior half by the fold which is nearly flat across top and sharply defined by sides of the outer plications of the fold. In the large forms the fold is not flat as the outer plications occur on the sides of the fold, but it is still sharply defined. The beak of the brachial valve is imbedded in the pedicle valve. The ornament of the brachial valve is of the same nature as that on the pedicle valve, usually with one more plication on the fold than on the sinus and one less on each flank.

Internally (Pl. 2, figs. 6-9) the brachial valve has a median septum which is deeply divided and which extends anterior approximately to the point of strongest articulation of the valves. Each branch of the median septum supports the inner edge of an apparently perforated hinge plate, (fig. 8). The hinge plate begins as narrow upright extensions of the sides of the brachial valve (fig. 6) which may or may not meet over the crural cavity. (Sections of one specimen out of three shows the crural cavity roofed at this stage (fig. 10)). Small processes grow inward and up from each inner wall of the crural cavity, and become the inner edges of the now divided hinge plate (figs 8 & 12). Simultaneously the hinge plate expands laterally forming strong sockets. At approximately the point of strongest development of articulation, the hinge plate becomes continuous once again over the crural cavity (fig. 9). At this stage, or very little anterior to it, the median

septum and its branches thin and disappear, as do the dental lamellae of the pedicle valve. Anterior to these features the only internal structure is the solid hinge plate which continues for approximately 0.3 mm., at which point crura develop anterior to the thickest portions of the hinge plate.

It is considered probable that the hinge plate may be continuous in these forms, but that the median portion, which is very delicate at all times, was not wholly preserved in the three specimens sectioned. A smaller shell, considered to be an immature form, showed a divided median septum which disappeared sooner, (figs. 1-3), the branches of it becoming lamellae connecting the hinge plate to the floor of the brachial valve on each side of a median ridge, (figs. 3,4) not unlike the early sections of the mature specimens.

Table of dimensions.

			No. of Plications	
Length	Width	Depth	Flank of pedicle valve	Sinus
9½	10	4	9	4, one on wall
9	10½	4½	8	3
9½	10	5	7 or 8	3
9	10½	5	8	3
10	11½	5	7	3
10	11	6	8	3
10	11	6	9	4, one on wall
11	12	5½	8	4, one on wall
11	12½	8	8	4, one on each wall
11½	12	8	7 or 8	3
11	11	8	8	3
9½	10½	7	6	3
12½	13	6½	7 or 8	2

The smaller, probably immature, specimens are listed first. The last two are somewhat anomalous.

Remarks. The similarity of the above external details to forms described by Hyde (14) as Rhynchopora altiplicata from the Vinton member of the Logan formation (Burlington?) of Ohio is sufficiently close to suggest that the two are the same. Hyde did not determine the nature of the internal features or whether or not the shell substance is punctate.

The same may be said of the external features of Allorhynchus acutiplicatum Weller (31), but serial sections of that form show that the median septum of the brachial valve is missing and that the hinge-plate is divided throughout.

If future work shows these forms to have perforated hinge-plates consistently, a new genus will probably result. If it is found that the hinge-plates may or may not be perforated, such forms as these may prove a relationship between those genera with a divided hinge-plate (Camarotoechia, Allorhynchus) and those with a solid hinge-plate (Greenockia).

Occurrence. Member 2 of Rundle fm. of sections 6, 7 and 9; locs. 6-2, 7-3, 9-1.

Greenockia sp. C

Pl. 2, figs. 13-16; Pl. 7, figs. 28-32

Description. Valves approaching equality in depth but brachial valve noticeably deeper. Costate throughout. Impunctate.

Pedicle valve strongly convex transversely over beak, becoming moderately convex by mid length where sinus begins. Sinus is rounded to nearly flat transversely and commonly ill defined when a plication occurs on each wall. Always well defined at anterior. Anterio-lateral flanks gently to moderately convex transversely. Longitudinally, pedicle valve is moderately and uniformly convex from top of beak to

anterior edge of sinus, and gently convex from beak to anterior along the top of the bounding plications. The beak is moderately incurved. Outline of pedicle valve is much the same as that of sp. B, being subtrigonal with flat posterio-lateral margins and broadly rounded anterior. Widest nearer anterior than sp. B. Pseudocardinal areas marked but small as in sp. B. Ornament consists of simple, radial costae rounded over umbo, becoming acutely angular with sharply rounded crests toward anterior. Very fine concentric ornament seldom preserved. When exfoliated, crests of costae in sinus usually slightly depressed or flattened. Eight or nine costae occur on flanks and from 3 to 5 in sinus.

Internally, dental lamellae are well developed, (Pl. 2, figs. 13-16).

Brachial valve is strongly convex transversely and longitudinally. Fold is developed in anterior half, is gently rounded transversely, and sharply defined near anterior only. The beak of the brachial valve is imbedded in the pedicle valve. The ornament is like that of the pedicle valve with usually one more plication on the fold than on the sinus and one less on each flank.

Internally this valve is essentially as in sp. B, but the one specimen sectioned showed a median septum and branches which disappeared well before the articulation developed most strongly. (Pl. 2, figs. 13-16). Nature of crura unknown.

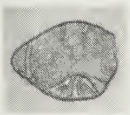
Plate 2

Serial Sections of Greenockia spp. B and C.

Figures 1, 12. Greenockia sp. B: 1-5, an immature ? specimen of this species showing short, split median septum (2), and continuous hinge-plate opposite strongest articulation (4,5): 6-9, a mature specimen showing deeply divided median septum, its branches supporting the inner edges of an apparently perforated but obviously distorted hinge-plate (8); the hinge plate is solid and covers the crural cavity as the articulation is strongly developed (9): 10-12 another mature specimen showing a covered crural cavity in early sections (10,11) and the hinge-plate divided later (12). Continuation of grinding showed the hinge-plate to become solid as the medium septum disappeared. (Page 92)

Figures 13-16. Greenockia sp. C. The median septum is short, having disappeared well before articulation develops. Remnants of the branches of the median septum are shown on the inner sides of the incipient hinge-plate (14). The hinge-plate becomes continuous as articulation is developed (16). (Page 95)

Plate 2



1 x7

2 x6

3 x5

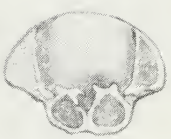
4 x5

5 x5

6 x5

7 x10

10 x8



8 x5

11 x8

9 x5

12 x8

13 x5

14 x5

15 x5

16 x5

Table of dimensions.

Length	Width	Depth	No. of Plications: Flank of pedicle valve	No. of Plications: Sinus
8.5	9	6.0	8	4
9.5	10.5	7.7	9	4
10.8	11.2	8.4	8 or 9	5, one on wall
11.5	12.2	8.4	?	3

Remarks. The depth and convexity of the pedicle valve apparently distinguish this form from all other Rhynchonellids except Camarotoechia metallica as illustrated by Girty (11), from which it differs externally in having the maximum width nearer the anterior.

Occurrence. Member 2 of Rundle fm. of section 9; loc. 9-1.

Greenockia? sp. D

Pl. 8, figs. 1-4

Description. The largest Rhynchonellid found. Length, 12½ mm.; width 16 mm.; depth 10.5 mm. Valves very unequal, the pedicle valve nearly flat, the brachial obese. Surface coarsely costate throughout. Shell substance apparently impunctate.

Transversely, the pedicle valve is deeply convex over the small beak, becomes shallowly convex over umbo and nearly flat from side to side at point of maximum width just anterior to mid length. Sinus begins just anterior of mid-length and becomes deep rapidly and is extremely so at anterior where its plane makes approximately a right angle to the plane of lateral commissure. Walls of sinus are the abrupt flanks of the boundary costae. Antero-lateral flanks flat on top sloping very gently laterally. Longitudinally, pedicle valve is evenly convex, ascribing 1/3

of a circle from beak to anterior of sinus. From umbo to anterior along flanks, the valve is nearly flat. The beak is narrow, protruberant and apparently pointed and moderately incurved. The posterio-lateral margins are gently but definitely concave, the lateral margins, from just posterior to the maximum width to the edge of the sinus, are evenly rounded; the anterior margin (the sinus) is flat. The pseudo-cardinal areas are small. The ornament of the pedicle valve consists of costae, fine and rounded on the beak, becoming coarse and acutely angular with sharply rounded or slightly flattened or depressed crests (shell exfoliated anteriorly). Seven costae occur on flanks, 5 of these visible in a pedicle view, the other 2 actually on the posterio-lateral margin. Four costae occupy the floor of the sinus. Internally, dental lamellae are present.

The brachial valve has steep vertical flanks along the postero-lateral margin, and a slight medial depression near the beak. At mid length the valve is strongly and evenly convex. The fold begins about mid length and soon becomes well defined being bounded by abrupt flanks of the outer costae of the fold. The top of the fold is apparently gently curved transversely. The antero-lateral flanks are deeply convex and nearly vertical at the line of commissure. Longitudinally this valve is moderately convex from the beak to the anterior margin of the fold and deeply convex from the beak over the flanks to the anterior. The beak is imbedded in the pedicle valve. The ornament on this valve is of the same nature as that on the pedicle. Six or 7 costae occur on each flank, five surmount the fold. Interior unknown.

Remarks. This form varies from species B in being larger, and relatively deeper. It may be the true nature form of that species, but no transitional forms were found. It resembles Weller's illustration of Rhynchopora pustulosa (plate 24, fig. 82) quite closely but is a little smaller and is impunctate.

Occurrence. Member 2 of Rundle fm. of section 6; loc. 6-2.

Genus, DIELASMA King, 1850

Dielasma cf. chouteauensis Weller

Pl. 8, figs. 5,6

1914, Dielasma chouteauensis Weller, Mon. Ill. State Geol. Surv., vol. 1, p. 257, pl. 33, figs. 1-17.

Remarks. Forms are referred to this species with some doubt. A slightly crushed specimen has a length of 22 mm., a width of 13 mm., and a depth of 10 mm. The smallest specimen of this species figured by Weller is one half again as large. The anterior margins of Weller's forms are rounded whereas in these it is more nearly straight. Otherwise the resemblance is closer than to any other species checked.

Occurrence. Uppermost beds of the Banff fm. in section 1; loc. 1-1. Chouteau limestone, Missouri.

Genus, PLATYRACHELLA Fenton and Fenton, 1924

Platyrachella rutherfordi (Warren)

1932, Spirifer rutherfordi Warren, Trans. Roy. Soc., Canada, 3rd ser., vol. 26, sec. 4, p. 247, pl. 2, figs. 1-4.

1952, Platyrachella rutherfordi Brown, G.S.C. Mem. 264, p. 94, pl. 5, figs. 6a-3

Remarks. One pedicle valve and one complete shell referred to this species agree in all details with Warren's and Brown's descriptions except that the fine radial ornament referred to by Brown as rows of tubercles appear to be merely striations.

Occurrence. Upper 50 feet of Banff formation at section 5; loc. 5-1; and at the same horizon between sections 6 and 7.

Platyrachella sp.

Remarks. Small brachial valves, the largest 25 mm. wide and 10 mm. long, have a depression along the center of the otherwise unornamented fold. One detached pedicle valve believed to be of the same species has an unornamented sinus. About 13 plications occupy the flanks. The fine surface ornament is usually missing due to exfoliation but no fine radial striations appear to be present.

Occurrence. Member 2 of the Rundle fm., section 7; loc. 7-4

Genus, SPIRIFER Sowerby, 1815

Spirifer albertensis Warren
Pl. 8, fig. 7

1932, Spirifer albertensis Warren, Trans. Roy. Soc., Canada, sec. 4, vol. 26, p. 244, Pl. 1, figs. 7-14.

Remarks. Two brachial valves and one pedicle valve are assigned to this species on the basis of the frequency of bifurcation of lateral costae and a mucronate extension shown by one specimen.

Occurrence. Uppermost beds of the Banff formation in sections 1 and 8; locs. 1-1 and 8-1.

Spirifer centronatus Winchell, 1875
Pl. 8, figs. 8,9,10

1875, Spirifer centronatus Winchell, Proc. Acad. Nat. Sci. Philadelphia, p. 118.

1899, Spirifer centronatus Girty, Mon. 32, U.S.G.S., pt. 2, ch. 12, p. 547, pl. 70, figs. 3a-d.

Remarks. Specimens assigned to this species are imperfectly preserved but appear to conform to Girty's description in the number of plications (16) on the flanks, in the convexity, and in the strength of the beak. Plications in the sinus originate as in S. centronatus, but the valves are a little longer than Girty's figures, and within this extra length, two of the original three plications bifurcate and a total of seven plications occur in the sinus at the anterior. Girty described a maximum of five.

Occurrence. Member 2 of the Rundle formation of sections 6 and 9; locs. 6-2 and 9-1. Madison limestone, Montana.

Spirifer minnewankensis (Shimer) 1926
Pl. 8, figs. 11-16

1926, Spirifer centronatus var. minnewankensis Shimer, Geol. Surv. Canada, Bull. No. 42, 1926.

1952, Spirifer minnewankensis Brown, Geol. Surv. Canada, Mem. 264.

Remarks. Specimens assigned to this species agree with Brown's description and illustrations very well. They differ from S. centronatus in the same details as mentioned by Brown. This species is the most abundant brachiopod collected.

Occurrence. Member 2 of the Rundle fm. in sections 6, 7, 8 and 9; locs. 6-2, 6-3, 7-1, 7-3, 8-5 and 9-1. Member 4 of the Rundle fm. in section 6; loc. 6-5. Uppermost bed of the Banff formation in section 8; loc. 8-1.

Spirifer cf. minnewankensis
Pl. 9, figs. 1,2

Remarks. An extremely divergent form with a shallow sinus and a low fold which fits Shimer's S. centronatus var. minnewankensis more closely than Brown's S. minnewankensis. However, the number of plications on the flanks is commonly 20 to 24, about average for Brown's species. The convexity is low and the beak small. Dimensions of an average specimen are: length 17 mm., width about 50 mm., convexity of pedicle valve 5 mm. This form is probably the unidentified species of Spirifer illustrated by Girty (11) on plate 70 (fig. 1a).

Occurrence. Member 2 of Rundle formation of sections 6 and 7; locs. 6-1, 7-3 and 7-4.

Spirifer missouriensis Swallow, 1860.

1860, Spirifer missouriensis Swallow, Trans. St. Louis, Acad. Sci. vol. 1, p. 643

1914, Spirifer missouriensis Weller, Mon. 1, Ill. State Geol. Surv., p. 319, pl. 39, figs. 11-23.

Remarks. One pedicle valve appears identical to Weller's figures and description especially with regard to fasciculation and strength of costae. The cardinal area and extremities are not revealed.

Occurrence. Uppermost bed of the Banff fm. of section 1; loc. 1-1. Chouteau limestone, Missouri.

Spirifer cf. missouriensis

Remarks. Eight brachial valves, in general fairly well preserved, tend to have semicircular to semielliptical outlines. These are referred to S. missouriensis as they show an intensity of bifurcation and trifurcation surpassing that of S. albertensis Warren, and fasciculation

is present although rather indistinct. The radial ornament is a good deal finer than on Weller's figures of S. missouriensis and the length proportionately greater. These forms differ from S. esplanadensis (3) Brown in being smaller, (Average dimensions: length 17 mm., width 21 mm., depth of brachial valve 4 mm.), having less intensive bifurcation and trifurcation, and in having the maximum width at the hinge line.

Occurrence. Member 2, Rundle fm. of section 7; loc. 7-4.

Genus, BRACHYTHYRIS McCoy, 1844

Brachythyris chouteauensis Weller, 1914

1914, Brachythyris chouteauensis Weller, Mon. 1, Ill. State Geol. Surv., p. 373, pl. 57, figs. 4-11.

Remarks. A lateral half of a shell appears to agree fully with Weller's species except that this form has only 7 plications on the flanks compared with 8-11 on Weller's.

Occurrence. Member 2, Rundle fm. section 6; loc. 6-1. Kinderhook in Mississippi Valley.

Genus, SPIRIFERELLA Chernuishev

Spiriferella minnewankensis Shimer, 1926

1926, Spiriferella minnewankensis Shimer, Geol. Surv. Canada, Bull. No. 42, p. 64, pl. 3, figs. 1a-d, 2a-c.

Remarks. Forms assigned to this species agree fully with Shimer's description and illustrations in all except for the three plications on the sinus which are missing on the specimens studied here.

Occurrence. Member 2 of the Rundle fm. of section 9; loc. 9-1. Upper part of "Lower Rundle" at L. Minnewanka.

Genus, TORYNIFER Hall and Clarke, 1895

Torynifer cf. pseudolineata (Hall)

1858, Spirifer pseudolineatus Hall, Geol. Iowa, vol. 1, pt. 2, p. 645, pl. 20, fig. 4.

1914, Reticularia pseudolineata Weller, Mon. 1, Ill. State Geol. Surv., p. 429, pl. 74, figs. 1-11, and pl. 75, fig. 20.

1952, Torynifer pseudolineata Brown, G. S. Canada Mem. 264, p. 102.

Remarks. Specimens referred to this species are on the whole poorly preserved. There are a few well enough preserved to show the features mentioned below. The main criteria relied on are the outline and the prominent, fine, internal, radial striae. The sinus and cardinal area are as shown by Weller. However the largest and best preserved specimen is only three-quarters the size of that measured by Weller, and the beak is more erect than shown by his figures. T. pseudolineata var. jasperensis Brown[3] apparently has a smaller cardinal area and a more definite pedicle sinus, and more sharply rounded sides. T. cooperensis (Swallow), as described by Weller, has much less prominent radial striae, a smaller cardinal area and a shallower sinus. Also, the divergence of the dental lamellae appears to be about 30 degrees in these specimens, whereas that of T. cooperensis is from 20 to 25 degrees. Thirty degrees is the minimum stated for T. pseudolineata by Weller.

Occurrence. Upper Banff of section 5; loc. 5-1. Member 2 of the Rundle formation in section 7; locs. 7-3, 7-1.

Genus, PUNCTOSPIRIFER North, 1920

Punctospirifer solidirostris (White), 1860

1860, Spirifer solidirostris White, Jour. Boston Soc. Nat. Hist., vol. 7, p. 232.

1914, Spiriferina solidirostris Weller, Mon. Ill. State Geol. Surv., vol. 1, p. 29, pl. 36, figs. 25-34.

1952, Punctospirifer solidirostris Brown, Geol. Surv. Canada, Mem. 264, p. 103.

Remarks. An incomplete pedicle valve is assigned to this species on the basis of the nature of the ornament and the presence of a median plication in the sinus.

Occurrence. Uppermost bed of the Banff fm. of section 8; loc. 8-1. Kinderhook of Iowa. Madison of Montana.

Punctospirifer cf. subtexta (White), 1860

1860, Spirifer subtexta White, Proc. Boston Soc. Nat. Hist., vol. 9, p. 25.

1914, Spiriferina subtexta Weller, Mon. Ill. State Geol. Surv., vol. 1, 1914, p. 291, pl. 36, figs. 35-40.

1952, Punctospirifer subtexta Brown, Geol. Surv. Canada, Mem. 264, p. 103.

Remarks. Part of a pedicle valve showing no ornament in the sinus and concentric ornament more strongly developed than on P. solidirostris, is referred to this species.

Occurrence. Member 2 of Rundle fm. of section 9; loc. 9-1. Osage (Burlington ls.) and Kinderhook of Iowa.

Genus, CLEIOTHYRIDINA Buckman, 1906

Cleiothyridina cf. tenuilineata (Rowley), 1900

1900, Athyris tenuilineata Rowley, Am. Geol., vol. 25, p. 264, pl. 5, figs. 31-33.

1914, Cleiothyridina tenuilineata Weller, Mon. Ill. State Geol. Surv., vol. 1, p. 478, pl. 80, figs. 1-12.

Remarks. Specimens referred to this species are not well enough preserved to permit positive identification. The radially arranged spines

are represented by low plications towards the anterior, are uniform, and four of them occur in 1 mm. C. hirsuta has slightly coarser radial ornament, 3 occupying one mm. according to Weller.

Occurrence. Uppermost beds of Banff fm. of sections 1 and 8; locs. 1-1 and 8-1. Member 2 of the Rundle fm. in sections 7 and 9; locs. 7-4 and 9-1.

Genus, COMPOSITA Brown, 1849

Composita cf. athabaskensis Warren, 1932

1932, Composita athabaskensis Warren, Trans. Roy. Soc., Canada, 3rd ser., vol. 26, sec. 4, p. 248, pl. 2, figs. 5-11.

Remarks. Specimens referred to this species are equal in size to the smallest illustrated by Warren. They have the same relative depth which seems to be a distinctive feature. The outline corresponds except for the anterior margin which is not straight as in Warren's specimens, but rather narrowly rounded.

Occurrence. Member 2 of Rundle fm. of section 7; locs. 7-1 and 7-3.

Composita humilis (Girty), 1899
Pl. 9, figs. 3-5

1899, Seminula humilis Girty, U.S. Geol. Surv., Mon. 32, pt. 2, p. 565, pl. 71, figs. 6a-c.

1952, Composita humilis Brown, Geol. Surv. Canada, Mem. 264, p. 105.

Remarks. Specimens assigned to this species compare very well with Girty's illustrations, showing the same roundness of outline, near equality of valves and strength of beak.

Occurrence. Upper beds of Banff fm. of sections 1, 5 and 8; locs. 1-1, 5-1 and 8-1. Member 2 of Rundle fm. in sections 6, 7 and 9; locs. 6-2, 7-1, 7-4 and 9-1. Madison ls., Montana.

var.
Composita humilis A n. var
Pl. 9, figs. 6-10

Remarks. This variety is typified by the marked inequality of the valves, a strongly convex pedicle umbo, and a large, well incurved beak. It differs from C. humilis (Girty)[11] in the greater depth of the pedicle valve, the presence of a faint sinus and fold in the anterior one-third, the more strongly incurved beak, and in the rounded, subquadrate outline. From C. subtilita (Girty)[11] these forms are distinguishable by their nearly equal length and width, but the longitudinal outline is more nearly that of C. subtilita than any other species checked. C. athabaskensis Warren[29] is proportionately longer and thinner. C. athabaskensis var. esplanadensis Brown[3] has the same outline and is only slightly less deep, but the brachial valve is more convex than the pedicle whereas in this form the pedicle valve is markedly larger and more convex.

This variety is assigned to the species C. humilis because of its nearly round outline, its prominent beak and its overall proportions, but because of the differences mentioned above, it is not a C. humilis in the strict sense.

Table of dimensions.

	Catalogue Number	Length of Pedicle Valve	Length of Brachial Valve	Width	Depth
Holotype	1-70-e-1	14 mm.	13 mm.	14 mm.	10 mm.
Paratype	1-70-e-1	17 mm.	15.5 mm.	16.5 mm.	11.5 mm.
Paratype	1-70-e-3	13.5 mm.	12.5 mm.	13 mm.	9.5 mm.
Paratype	1-70-e-4	13 mm.	11.5 mm.	13 mm.	8.5 mm.
Paratype	1-70-e-5	12.5 mm.	11.5 mm.	12 mm.	7.5 mm.
Paratype	1-70-e-6	9.3 mm.	8.4 mm.	8.8 mm.	5.5 mm.

Young forms assigned here show a variety of outline from longer than wide to wider than long, but all show the typical overhanging, incurved beak.

Occurrence. Top beds of Banff fm. of section 1; loc. 1-1. Member 2 of Rundle fm. in sections 6 and 7 (identification not positive); locs. 6-2, 7-3 and 7-4.

Composita immatura (Girty), 1899

1899, Seminula immatura Girty, U.S. Geol. Surv., Mon. 32, pt. 2, p. 566, Pl. 71, figs. 5a-d.

1952, Composita immatura Brown, Geol. Surv. Canada, Mem. 264, p. 105, pl. 5, figs. 4a,b.

Remarks. Specimens assigned to this species are smaller than Girty's by about one quarter. They compare well with Brown's (3) specimens.

Occurrence. Top beds of Banff fm. of section 1, loc. 1-1.

Composita trinuclea (Hall), 1856
Pl. 9, figs. 11-15

1856, Terebratula trinuclea Hall, Trans. Alb. Inst., vol. 4, p. 7.

1914, Composita trinuclea Weller, Mon. Ill. Geol. Surv., vol. 1, p. 486, pl. 81, figs. 16-45.

Remarks. A single specimen with the anterior extremity missing is assigned to this species as it shows a narrow umbonal area, a pointed, moderately incurved beak and a subangular sinus inthe anterior half of the pedicle valve and a corresponding flat topped fold on the brachial valve.

Occurrence. Member 2 of Rundle fm. in section 9; loc. 9-1. Salem ls. and higher in Iowa.

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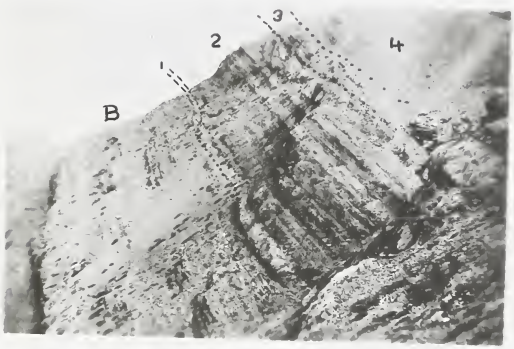
(32) _____ Faunal Zones in the Standard Mississippian Section; Jour. of Geol. vol. 34, pp. 320-355. (1926)

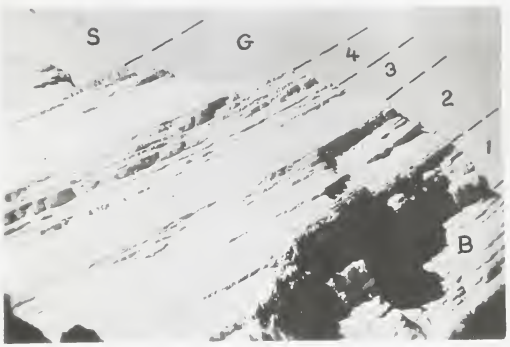
Plate 3



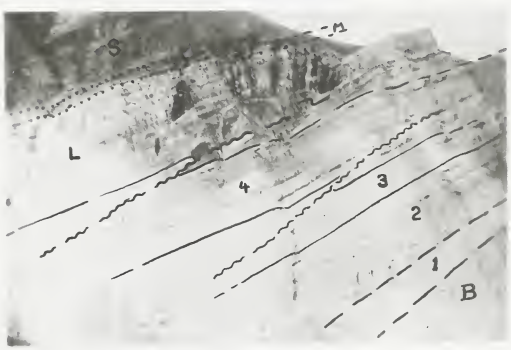
A. Massive units 1, 2 & 3 of the Rundle formation in section 2 overly the Banff formation (B), which contains the massive bed near left side of photograph.

B. Lower member of Greenock formation in section 1, showing massive nature of lower part, and easily weathering shaly intervals in upper part. Bedded interval at base of cliff in foreground is transition zone from Rundle formation below.

Plate 4

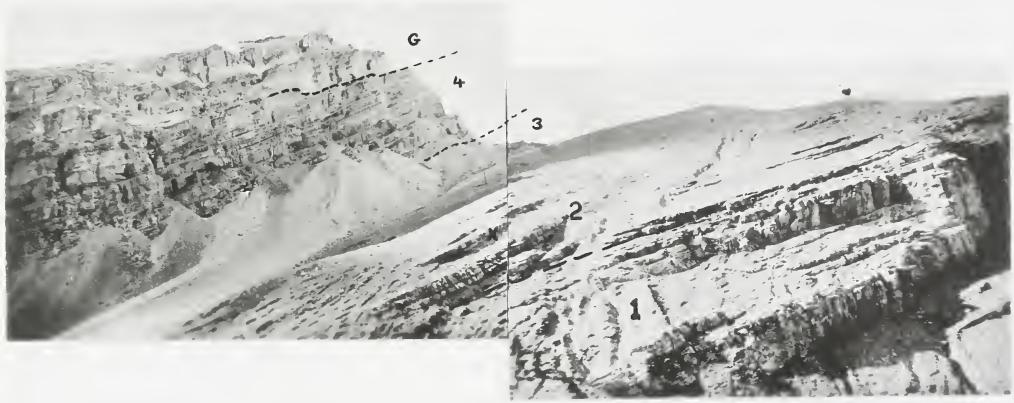


A. A ridge of mount Valley Head about 1 mile north of traverse of section 5. Spray River formation (S), Greenock formation (G), 4 units of the Rundle formation, and the Banff formation (upper third) are shown.



B. Section 6. Banff (B), units 1 to 4 of the Rundle, Lower (L) and Middle (M) members of the Greenock formation, and the Spray River formation (S), are shown.

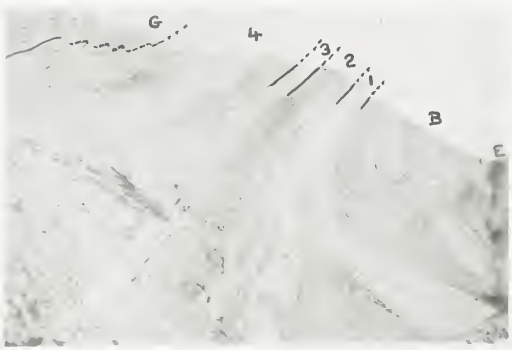
Plate 5



Section 7. Middle member of the Greenock formation is shown as a thin, dark bed capping section at uppermost center of left photograph. Greenock formation (G), 4 units of Rundle formation, and the upper beds of the Banff formation (covered interval at lower right), are shown.

Plate 6

A. Section 9. Spray River formation overlies Middle member (M) of the Greenock formation. Lower member (L) of the Greenock formation, and unit 4 of the Rundle formation are shown.



B. Section 9. The Lower member of the Greenock formation (G), the 4 units of the Rundle formation, the Banff formation (B), and the Exshaw (E) formation are shown.

Plate 7

All figures are natural size unless otherwise stated.

Figures 1, 2. *Chonetes* sp. Internal mold of pedicle and brachial valves. (Page 83)

Figures 3-7. *Avonia* cf. *indianensis* (Hall): 3 and 4, lateral and pedicle views of pedicle valves of average size: figure 4 has an auricular portion preserved: 5 and 6, pedicle and anterior views of a large specimen: 7, interior of a brachial valve. (Page 84)

Figures 8-11. *Dictyoclostus sedaliensis* Weller. Brachial, posterior, lateral and pedicle views. Figure 11 is smaller than natural size. (Page 87)

Figures 12-16. *Greenockia* sp. A. Pedicle, brachial, lateral, anterior and posterior views. (Page 90)

Figures 17-27. *Greenockia* sp. B: 17-22, pedicle, brachial, lateral (3,4), anterior and posterior views of specimens believed to represent the mature form of this species: 23-27, pedicle, lateral (2,3), anterior and posterior views of smaller (probably immature) forms of this species. (Page 92)

Figures 28-32. *Greenockia* sp. C. Pedicle, brachial lateral anterior and posterior views. (Page 95)

Plate 7

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17 18 19 20 21 22

23 24 25 26 27

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Plate 8

All figures are natural size.

Figures 1-4. Greenockia ? sp. D. Pedicle, lateral, anterior and posterior views. (Page 97)

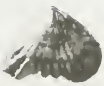
Figures 5-6. Dielasma cf. chouteauensis Weller. Pedicle and lateral views. (Page 99)

Figure 7. Spirifer albertensis Warren. Brachial view showing bifurcation of costae and mucronate cardinal extremity. (Page 100)

Figures 8-10. Spirifer centronatus Winchell. Pedicle, lateral and posterior views. (Page 101)

Figures 11-16. Spirifer minnewankensis Shimer: 11-14, pedicle, lateral, posterior and brachial views: 15, pedicle and brachial valves: 16, anterior view. (Page 101)

Plate 8



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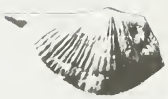

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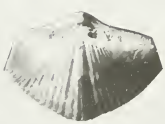

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Plate 9

All figures are natural size.

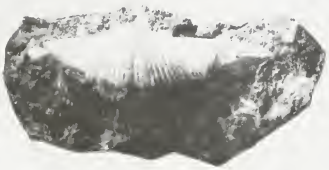
Figures 1, 2. *Spirifer* cf. *minnewankensis* Shimer. Pedicle and brachial views. (Page 102)

Figures 3-5. *Composita humilis* Girty. Pedicle, lateral and posterior views. (Page 106)

Figures 6-10. *Composita humilis* var. A n. var. Pedicle, brachial, anterior, lateral and posterior views of holotype. (Page 107)

Figures 11-15. *Composita trinuclea* (Hall). Pedicle, brachial, anterior, lateral and posterior (pedicle valve down) views. (Page 108)

Plate 9



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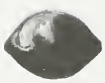

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